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AND THEIR

ADMINISTRATION.

A Manual for Medical and Dental Practitioners and Students.

BY

FREDERIC W. HEWITT, M.A., M.D. Cantab.
ANÆSTHETIST AND INSTRUCTOR IN ANÆSTHETICS AT THE LONDON HOSPITAL; ANÆSTHETIST AND LECTURER ON ANÆSTHETICS AT CHARING CROSS HOSPITAL; ANÆSTHETIST AT THE DENTAL HOSPITAL OF LONDON, AND AT THE NATIONAL ORTHOPÆDIC HOSPITAL.

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TO

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PREFACE.

The following pages have been written in the hope that they may prove of service to those practitioners and students who wish to obtain information concerning the administration and effects of general anæsthetics.

Until within the last few years, systematic instruction in this branch of practice was almost unknown; and even at the present time the opportunities which a student has of making himself proficient in the use of anæsthetics are, with rare exceptions, lamentably inadequate. It thus happens that numerous recently qualified practitioners leave their hospitals possessing but the scantiest knowledge of the subject; and, owing to the bewildering mass of literature which exists, and to the difficulty of extracting any really practical information from it, they regard all further attempts at self-instruction as hopeless, and resort to the simplest rather than to the safest plans of anæsthetising their patients.

My principal object, therefore, has been to present to the practitioner a clear and yet detailed description of the best methods of inducing and maintaining surgical anæsthesia in ordinary cases; to indicate what modifications in procedure should be resorted to on exceptional occasions; and to systematically consider the chief difficulties and dangers connected with general anæsthetics, and the proper manner in which they should be met. I have endeavoured, in fact, to make the book one to which reference may be made when any doubt exists as to the anæsthetic which should be given in any particular case. Supposing that a certain type of patient has to undergo a certain operation, and that the practitioner has not had much experience in the use of anæsthetics, it is believed that he will find, by referring to these pages, practical hints which may materially assist him in the conduct of the case.

Another object which I have had in view has been to assist the student in acquiring that knowledge which is essential before he actually administers an anæsthetic for a surgical operation. I have tried, as far as possible, to give him the information of which he seems most in need, if I may judge by the questions which are most frequently put to me whilst engaged in instructing students in the operating theatres of the hospitals with which I am connected.

I may add that I commenced collecting materials for this work just ten years ago. During this period I have taken as accurate notes as possible of every case which has presented points of interest, and have made comparative trials of all the best known methods of producing anæsthesia. In this manner I have attempted to give a solid clinical foundation to every conclusion which I have ventured to put forward.

About a year before going to press I received from Dr. W. J. Sheppard of Putney the collection of Note-books left by his brother, the late Dr. C. E. Sheppard, one of the anæsthetists at the Middlesex Hospital and at the Guy's Hospital Dental School. These Note-books contain most carefully recorded notes of 2350 administrations. I felt that I could pay no better tribute to the memory of one whose friendship it was my privilege to enjoy, and whose loss so many must regret, than by going most thoroughly through these notes, and extracting what I considered to be most important. By the kind assistance and guidance of Dr. W. J. Sheppard, I have been able to bring together all the valuable observations made by his brother upon the pupil under chloroform, and upon many other points connected with the effects of anæsthetics; and I have incorporated these observations with my own.

In my endeavours to make this a clinical and practical treatise, I have thought it best to exclude much that might at first sight appear to be essential. Thus it will be found that only the more important general anæsthetics have been considered; that no detailed reference has been made to the discovery and history of the various means which have been employed for the prevention of pain; and that no attempt has been made, either to discuss the action of anæsthetics from a purely experimental point of view, or to harmonise clinical and physiological facts. All these aspects of the subject, although of great interest *per se*, are beyond the aim of the present volume, and have therefore been omitted.

In conclusion, I am desirous of expressing my best thanks to Mr. Marmaduke Sheild and Mr. George Rowell for the very valuable assistance they have given me in passing the work through the press.

FREDERIC W. HEWITT.

10 GEORGE STREET, HANOVER SQUARE, W.,
July 1893.

KEY TO GENERAL ARRANGEMENT OF BOOK.

Part I.—Preliminary Considerations.

Chap. I.	Chap. II.	Chap. III.	Chap. IV.	Chap. V.
The properties and impurities of the chief agents capable of producing general anæsthesia.	The general condition of the patient.	The nature of the operation, procedure, or condition for which anæsthesia is desired.	The selection of the anæsthetic and the method of its administration.	The preparations for the administration.

Part II.—The Administration of the Selected Anæsthetic.

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Part III.—The Management and Treatment of the Difficulties, Accidents, and Dangers of General Anæsthesia.

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Minor difficulties.	The management and treatment of the difficulties, accidents, and dangers connected with respiration.	The management and treatment of the difficulties, accidents, and dangers connected with circulation.

Part IV.—The Condition of the Patient after the Administration.

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THE PROPERTIES AND IMPURITIES OF THE CHIEF AGENTS CAPABLE OF PRODUCING GENERAL ANÆSTHESIA.

A. NITROUS OXIDE.

Nitrogen monoxide (otherwise known as protoxide of nitrogen, nitrous oxide, or 'laughing gas') has a chemical formula of ON_2. It was first prepared by Priestley;[1] its properties were ably investigated by Sir Humphry Davy[2] in 1799–1800, who recognised its power of alleviating pain, and suggested that it might be used as an anæsthetic for surgical operations; and in 1844 it was employed for the production of surgical anæsthesia by Horace Wells, an American dentist.[3]

Properties.—Under ordinary circumstances nitrous oxide is a colourless, transparent, feebly refractive gas, with a peculiar sweetish odour and taste. It can be respired without any discomfort when the apparatus for its administration is properly constructed. When pure it is wholly devoid of irritant properties, so that it is particularly useful in cases in which other anæsthetics excite cough, swallowing, &c. The gas has a sp. gr. of 1.52[4] (Colin). A litre of it weighs 1.97172 grm.; or 100 cubic inches 47.29 grains. Water at 0° C. dissolves a little more than its own volume, but the solubility diminishes as the temperature of the water is raised. Nitrous oxide was first liquefied by Faraday in

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[1] Roscoe and Schorlemmer ('A Treatise on Chemistry,' 1884) give the date 1772: Watts ('A Dictionary of Chemistry') 1776.

[2] See 'Collected Works' of Sir Humphry Davy.

[3] For an excellent historical account of nitrous oxide the reader is referred to Dr. Silk's recent work on 'Nitrous Oxide Anæsthesia.'

[4] 1.495 (Watts).

1823. Liquefaction takes place under a pressure of 30 atmospheres at 0° C., or 50 atmospheres at 7° C. Liquefied nitrous oxide is a colourless, very mobile body, having a sp. gr. of .9369 at 0° C. (Andreef). Its boiling-point is stated by some observers to be – 87°.9 C., under a pressure of 767.3 mm. of mercury; whilst others place it at – 92° C. The steel and iron cylinders in which nitrous oxide is supplied by the manufacturers contain the agent in this liquid form. Roughly speaking, 15 oz. by weight of liquefied nitrous oxide will furnish 50 gallons of the gas. Solid nitrous oxide, in the form of compact snow, has been prepared by Wills,[1] who obtained it by a modification of Thilorier's method for preparing solid carbonic anhydride. The temperature of its freezing or melting point is stated to be – 99° C., as observed with an alcohol thermometer. As Dr. Sheppard pointed out,[2] the faulty working of nitrous oxide cylinders is often due to superficial solidification produced by the intense cold which results from the conversion of the liquid nitrous oxide into gas when the pressure within the cylinder is released. Nitrous oxide is not easily decomposed, a considerable elevation of temperature being necessary to split it up into its constituent gases. But when a burning body is placed in the gas, the latter is decomposed, and combustion is supported.

Impurities.—The nitrous oxide supplied for anæsthetic purposes is usually free from impurities. It is stated, however, that the gas has sometimes been found to contain **other oxides of nitrogen**, and **chlorine**. These gases, if present, would give the nitrous oxide an irritating odour and would induce coughing. The former impurities would be best detected by passing a slow stream of the nitrous oxide through a cold solution of ferrous sulphate acidulated with sulphuric acid; should the solution darken, the presence of other oxides of nitrogen would be indicated. Chlorine would be detected by its characteristic odour, and by its precipitating the chloride from a solution of argentic nitrate. Some writers state that 'sulphates' may be present as impurities in nitrous oxide; but it is difficult to understand their existence in the gas.

Liquefied nitrous oxide may be preserved for an almost indefinite time in iron or steel cylinders. Some administrators[3] have drawn attention to differences between the gas obtained from liquid nitrous oxide and that which has never been subjected to liquefaction. Such differences probably depend upon the absence of all traces of atmospheric air in the nitrous oxide which issues from the cylinders. If the nitrous oxide be kept in a gaseous form, even for a few days, admixture with air will be liable to occur, and although the gas may produce good anæsthesia, there may be an absence of that lividity and stertor which are met with when employing nitrous oxide absolutely free from oxygen.

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[1] *Chemical Society's Journal*, II. xii. 21.

[2] See foot-note, p. 92.

[3] See *Brit. Journ. Dent. Science*, Dec. 15, 1884 ('Anæsthetics and their Administration,' by J. W. Roberts, L.D.S.).

B. ETHER.

Ethyl oxide (otherwise known as ethylic ether, vinous ether, sulphuric ether, or simply ether) has a chemical formula of $C_4H_{10}O$, or $(C_2H_5)_2O$. According to Watts[1] it was first prepared by Valerius Cordius in 1540, who gave it the name of 'oleum vitrioli dulce.' Whilst there can be no doubt that the discovery of the anæsthetic properties of ether took place in America, it is difficult to state with certainty who first employed ether as an anæsthetic for a surgical operation.[2]

Properties.—Ether is a transparent, colourless, very mobile, and highly volatile liquid, possessing a characteristic pungent odour and burning taste. It is perfectly neutral to test-paper. It reflects light strongly. The sp. gr. of pure ether is .723 at 12°.5 C. (Watts), or .720 at 15°.5 C. (Fownes). At 0° C. it is said to have a sp. gr. of .7356 (Roscoe and Schorlemmer). According to Watts and Fownes it boils at 35°.6 C. (96° F.), under the ordinary atmospheric pressure; but other observers (Kopp and Andrews) give the boiling-point at 34°.9 C. Its vapour density is 2.586 (Gay-Lussac) as compared to air. Owing to its possessing such a high sp. gr., ether vapour may be poured from one vessel to another, and the process may be actually watched in bright sunlight. Some doubt seems to exist as to the possibility of solidifying ether by intense cold. Fourcroy and Vauquelin state that when ether is cooled to $-31°$ C. it crystallises in long white glistening tablets, which at $-44°$ C. form a continuous solid mass; but Mitchell found he was unable to freeze pure ether free from all traces of water by submitting it to a temperature of $-90°$ C. The balance of evidence seems in favour of Mitchell's views. Ether is freely miscible with alcohol, chloroform, and almost all other hydrocarbon derivative compounds. It is also soluble to a certain extent in water, 1 part dissolving in 10 at 11° C. One part of water, moreover, dissolves in about 34 parts of ether. Ether vapour is highly inflammable, and when mixed with air detonates violently on the approach of a burning body. It burns with a white luminous flame. These facts should be borne in mind, not only when administering in the neighbourhood of an artificial light, but when pouring the liquid from one bottle to another. Moreover, the actual cautery should never be used about the mouth or nose when the patient is under the full influence of ether.[1]

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[1] *Op. cit.*

[2] According to Dr. Buxton ('Anæsthetics, their Uses and Administration,' 2nd ed.), whose interesting historical account of the introduction of anæsthetics is well worth reading, ether was first administered for a surgical operation in 1842 by Dr. Long of Jefferson, Jackson Co., U.S.A. The merit of the discovery, however, is more usually ascribed to William T. G. Morton, an American dentist of Boston, and a pupil of Horace Wells.

Impurities.—Pure ethylic ether should be perfectly neutral to test-paper, and should evaporate without leaving any residue whatever. Many samples of the best methylated ether leave a distinct and pungent residue (see p. 7). It should, moreover, form a clear mixture in all proportions with oil of copaiba. Ether containing **water** or **alcohol** forms an emulsion with considerable quantities of the oil (Watts). The presence of water may also be detected by means of potassium phosphate, which is insoluble in anhydrous ether, but dissolves partially in ether containing water, a brown residue being left.[2] Tannic acid, which is insoluble in ether but soluble in water, is also used as a test for the latter. Alcohol is best detected by shaking the ether with water, which removes the alcohol; the aqueous extract is then gently warmed, a few crystals of iodine added, and then so much caustic potash that the solution just becomes colourless; after standing for a few hours, or at most a night, a bright yellow precipitate of iodoform will be thrown down, and the characteristic six-sided tablets or six-sided stellar groups may be examined microscopically.[3] By this test 1 part of alcohol in 2000 parts of water may be detected. The presence of **methylated ether** in pure ether is best detected by careful fractional distillation.[4]

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[1] Kappeler ('Anæsthetica,' p. 173) refers to a case at Lyons, in which, during the use of the cautery in the mouth, the ether vapour ignited. The face of the patient and the bag of the ether inhaler caught fire, and deep burns upon the face resulted. The case is also referred to in the *Brit. Med. Journ.*, vol. ii. 1879, p. 826. Mr. Marmaduke Sheild records a similar case (*Proc. Med. Soc.*, 1887, vol. x. p. 144), and states that he has also known the expirations of a patient under ether to become ignited by an adjacent lamp. See also two cases reported in 'Surgical Observations' by Dr. Warner.

[2] Romei, *Zeitschr. Anal. Chem.*, 1869, p. 390.

[3] See Roscoe and Schorlemmer, vol. iii. part 1, p. 318. See also Watts's 'Dictionary of Chemistry,' 2nd Supplement, 1875, Art. 'Ethyl oxide.'

[4] Ether prepared from methylated spirit commences to boil at a lower temperature than ether prepared from rectified spirit. See an article by Mr. H. W. Jones, F.C.S., on 'The Detection of Methylated Ether' (*Pharm. Journ. and Trans.*, vol. xvi. 1885–6, p. 663). It is stated that as little as 10 per cent. of methylated ether can thus be found. By removing the distillate

When ether has been preserved in an imperfectly stoppered bottle it is said to absorb oxygen, and to become acid from the presence of **acetic acid.** It is difficult, however, to understand this, for owing to extreme volatility of the drug, the contents of the bottle would soon altogether disappear. Should acetic acid be present, the ether would, of course, redden blue litmus paper, and an aqueous extract of it would give the reactions for acetic acid. A dark red coloration with ferric chloride is not characteristic of the presence of acetic acid, as formates and other bodies give this reaction as well. Roscoe and Schorlemmer state that the most characteristic test is the conversion of acetic acid into cacodyl oxide. "For this purpose the acid is saturated with caustic potash, evaporated with a small quantity of powdered arsenic trioxide, and the mixture heated in a test-tube, when the characteristic smell is perceived." Should the aqueous extract contain **sulphuric acid**, it may be detected by the white precipitate which it gives with baric chloride.

The pharmacopœial test for the purity of ether has given rise to much discussion. The Pharmacopœia states that "when shaken with a fourth of its bulk of solution of iodide of potassium and a little starch paste, no blue colour is produced." The question naturally arises: What impurities in ether is this test supposed to indicate? The question cannot at present be satisfactorily answered. Some have thought **aldehyde**,[1] others **ozone**,[2] and others again **peroxide of hydrogen** to be the cause of the liberation of iodine.[3]

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immediately the thermometer indicated 90° F., the following results were obtained:—

100 c.c. of each taken.	C.c. obtained.	Remarks.
Rectified ether, sp. gr. .720.	0	
Rectified ether, sp. gr. .730.	0	
Methylated ether, sp. gr. .717.	60	Boiled freely at 74° F.
Methylated ether, sp. gr. .720.	54	
Methylated ether, sp. gr. .730.	23	
Rectified (.735) and methylated (.730) in equal parts.	7	After cooling and again heating, a further 5 c.c. obtained.

[1] *Pharm. Journ. and Trans.*, 3rd ser., xv. p. 521.

[2] Ibid., xvi. p. 661.

[3] Ibid., xvii. p. 841. Prof. Dunstan and Mr. Dymond, who have devoted much attention to the matter, state that the amount of iodine liberated in a

According to Martindale,[1] the following kinds of ether are obtainable :—

(1.) *From Pure Rectified Spirit.*

(i.) *Æther* (Off.). Sp. gr. .735. Ordinary medicinal ether. Contains a little spirit and water. Not so suitable for inhalation as—

(ii.) *Æther Purus*[2] (Off.). Sp. gr. not exceeding .720. Absolute ether.

(2.) *From Methylated Spirit.*

(i.) *Absolute Ether—Methylated.* Sp. gr. .717–.719. Contains a little methylic ether, and is specially adapted for producing local anæsthesia, as it boils under 80°. Not adapted for producing general anæsthesia.

(ii.) *Rectified Ether.* From methylated spirit. Sp. gr. .720. Well washed to free it from methylic ether, purified, and re-distilled. Well adapted for producing general anæsthesia.

(iii.) *Methylated Ether.* Sp. gr. .730. For common purposes.

Putting on one side the first and third of the methylated ethers in the above list, which are used either for producing local anæsthesia or for common purposes, and which should never be employed for inhalation,[3] and putting on one side also the ether standing first of all on the list, which is rarely used for inhalation, we are left with 'Æther purus' of the British Pharmacopœia, and 'rectified ether from methylated spirit,' or, as it is sometimes termed, 'pure methylated ether.' Opinions are still divided as to the relative merits of these two ethers. There are some who unhesitatingly prefer the 'pure methylated ether' to that ob-

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given time is dependent upon the strength of the iodide solution—a point of importance in applying this test. They found, moreover, that whilst pure ether did not liberate iodine, ether prepared from methylated spirit quickly did so, even when the iodide solution was very dilute. They obtained from specimens of impure ether, by spontaneous evaporation, a pungent residue, which they found to contain peroxide of hydrogen in small quantities; and they believe that this peroxide of hydrogen is the body which reacts with the iodide solution. What the substance may be which gives rise to the hydrogen peroxide they cannot determine. One of the specimens of ether which left a pungent residue on evaporation had a sp. gr. of .741 and a boiling-point of 34° C. (93.2 F.). In the course of their experiments these observers found that even though pure ether was exposed to direct light for two months it failed to react with dilute iodide. They also passed a stream of oxygen for two days and a stream of air for some hours through pure ether with a similar result.

[1] 'Extra Pharmacopœia,' 1892.

[2] I am informed by Messrs. Robbins & Co. that the sp. gr. of their 'anhydrous ether,' which I have found to answer well, is .720, or is even a little below this, and that its boiling-point is as near as possible 95° F.

[3] A fatal result has been known to follow the administration of 'local anæsthetic ether' (see *Lancet*, Aug. 7, 1875). These impure ethers, when inhaled, produce much irritation, respiratory difficulty, cough, salivation, &c.

tained from rectified spirit.[1] There are others who hold exactly opposite views;[2] and there are others again who state that they can detect no difference in the effects of the two varieties.[3] I have for several years past administered both kinds of ether, with the object of carefully comparing the effects. I have often given the purer ether on one occasion and the methylated ether on another, to the same patient, and have noted the results. I have also given the ethers alternately during a prolonged administration and have watched the effects produced. My experience leads me to the conclusion that the purer ether is preferable. It produces less irritation, less mucus, less respiratory difficulty, and less after-nausea and vomiting than the best methylated brands. The vapour of pure ether, moreover, is less disagreeable than that of methylated ether. The so-called 'pure methylated ether,' which is, to my knowledge, very largely used at several of our hospitals, commences to boil at such a low temperature that in the summer time the heat of the hand is often sufficient to induce ebullition, methylic ether in a gaseous form apparently being evolved. This low boiling-point of 'pure methylated ether' has led many to infer that recovery from etherisation should take place more rapidly than after the use of ether prepared from rectified spirit. But this is questionable. There are impurities in most if not in all of the methylated ethers; and these remain behind, as it were, either in the inhaler or in the patient. The precise nature of such impurities is at present unknown. I have myself evaporated considerable quantities of 'pure methylated ether,' and can corroborate Prof. Dunstan's statement that a disagreeably smelling residue remains. Possibly fusel oil may be present in this residue. After a long administration of methylated ether some of this impurity must be inhaled by the patient. It is stated indeed by those who prefer methylated ether to the purer drug that patients remain longer under its influence than when ether prepared from rectified spirit has been used; and they urge that this is an advantage. It is, however, in my experience, the reverse of advantageous. A good and quick recovery from the effects of ether is to be encouraged, and such a recovery is to be looked for when the purest ether has been used. The comparatively tardy recovery from methylated ether (I am speaking of long administrations) is probably connected with the inhalation of impurities which are not to be found in 'Æther purus.'

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[1] The late Dr. Sheppard believed that he obtained better results with this than with the purer ether; and Mr. Bendelack Hewetson holds similar views (see *Lancet*, 1882, i. p. 1072).

[2] Mr. Bailey prefers the purest ether.

[3] Mr. Woodhouse Braine is of this opinion.

C. CHLOROFORM.

Trichlormethane, dichlorinated chloride of methyl, perchloride of formyl, commonly known as chloroform, has a chemical formula of $CHCl_3$. Liebig, Soubeiran, and Guthrie appear to have independently discovered chloroform[1] in the year 1831; but its real chemical composition was not ascertained till 1834, when Dumas[2] determined its true formula. It was first used as an anæsthetic by Sir James Simpson in 1847.

Properties.—Chloroform is a colourless, transparent, mobile, and volatile liquid, possessing a pleasant, penetrating odour, and sweet fiery taste. Its sp. gr. at 17° C. is 1.491 (Regnault); at 0° C. 1.52523 (Pierre). Chloroform obtained by crystallisation at an extremely low temperature (Pictet's process) is stated to have a sp. gr. of 1.5002 at 15° C.[3] The boiling-point of pure chloroform, according to Regnault,[4] is 60°.16 C.; according to Liebig, 61° C. Pierre states that chloroform boils at 63°.5 C., with the barometer at 772.52 mm. of mercury. Its vapour density, according to Dumas, is 4.199; according to Regnault, 4.230. Chloroform remains liquid and transparent at − 16° C. (Pierre), but may be solidified by the cold produced by its own evaporation. Chloroform dissolves in water to the extent of 1 part in 200, and is miscible in all proportions with alcohol, ether, and other organic liquids. It is not inflammable, but its vapour is decomposed when passed into a lighted spirit-lamp, and burns with a smoky flame, emitting fumes of hydrochloric acid.

Chloroform is found to be less liable to decomposition when a very small percentage of ethylic alcohol is added to it. The chloroform of the British Pharmacopœia therefore contains 1 per cent. by weight[5] of alcohol, and has a sp. gr. of 1.497.

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[1] According to Roscoe and Schorlemmer chloroform was discovered in 1831 by Liebig (*Pogg. Ann.*, xxiii. 444; *Ann. Pharm.*, i. 31, 198), and about the same time, but independently, by Soubeiran (*Ann. Chim. Phys.* [2], xlviii. 131; *Ann. Pharm.*, i. 272). The former considered it to be a chloride of carbon: the latter gave it the name 'éther bichlorique.' According to Watts ('Dictionary of Chemistry') Liebig's discovery was in 1832; but as Liebig strongly put forward his claims to priority (*Ann. Chem. Pharm.*, clxii. 161) it seems certain that, so far as he and Soubeiran were concerned, the discovery was almost simultaneous. Dr. Buxton ('Anæsthetics,' 2nd ed., p. 94) supports the claims of Samuel Guthrie.

[2] *Ann. Chim. Phys.*, lvi. 115; *Ann. Pharm.*, xvi. 164.

[3] Martindale's 'Extra Pharmacopœia.'

[4] *Jahresb.*, 1863, p. 70.

[5] Mr. David Brown Dott, writing on 'The Purity of Chloroform for Anæsthetic Purposes' (*Pharm. Journ. and Trans.*, 1882, p. 769), states that one-tenth per cent. of alcohol is sufficient.

Should alcohol be present to a greater extent than this the sp. gr. would, of course, be lower. It is stated that the chemically pure chloroform obtained by Pictet's freezing process does not require this addition of alcohol in order to preserve it;[1] but further research is necessary on this point.

Impurities.—A great deal of discussion has from time to time taken place concerning the nature of the impurities of chloroform, and the possibility of such impurities having been responsible in some cases for the supervention of dangerous or fatal symptoms during chloroformisation. Our knowledge upon the subject is at present very imperfect, and there is room for further investigation. Whilst impurities and decomposition products have undoubtedly been found in chloroform which has produced dangerous symptoms, such symptoms have often appeared under the influence of chloroform which has stood with credit the recognised tests of purity. In the present unsettled state of the subject it will therefore be best that we should confine ourselves to facts, and avoid all inferences as far as possible.

The chloroform used for anæsthetic purposes should conform to the following tests:—

1. It should possess a sp. gr. and boiling-point[2] such as have been already mentioned.

2. It should be perfectly transparent and colourless.

3. It should be absolutely neutral to test-paper.

4. It should possess an agreeable, bland, and non-irritating odour.

5. When a portion is allowed to evaporate spontaneously from a watch-glass it should leave no residue, either of water or of any substance possessing a strong smell.[3]

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[1] *Lancet*, Dec. 19, 1891: 'On a New Method of Purifying Chloroform,' by Réné du Bois-Reymond.

[2] Chloroform may be contaminated with substances possessing a higher or lower boiling-point than the chloroform itself. Thus Prof. Mentin of Warsaw (*Pharm. Journ. and Trans.*, 1888–9, p. 991) found, on taking 49 c.c. of a sample of chloroform which was obtained from a "respectable German house," that 6.5 c.c. came over at 59°–60° C., 30 c.c. from 60°–61°, and 12.5 c.c. above 61°. Other investigators have recorded similar results.

[3] Impure chloroform may leave a distinct residue when evaporated. For example, the residue of the sample referred to in the last foot-note weighed ·002 grm., and consisted of well-defined acicular crystals surrounded by a yellowish liquid. It had a most disagreeable odour of nitro-benzol and tobacco, and when inhaled produced giddiness and headache. After forty-eight hours the smell was replaced by that of benzoic acid. When the residue was heated on a watch-glass and partly evaporated, the remainder turned brown, and evolved a smell like that of burnt indiarubber. The chloroform from which this residue was obtained had caused alarming symptoms in one half of the cases in which it had been employed.

6. When shaken with concentrated sulphuric acid no brownish coloration, or only the faintest, should result.

7. It should form no precipitate with a solution of argentic nitrate.

8. It should not acquire a brown colour when heated to the boiling-point with caustic potash.

Other tests of purity have been suggested. Several years ago M. Yvon drew attention[1] to the fact that an alkaline permanganate solution, when added to impure chloroform, is changed from violet to green, whereas the violet colour is retained when the chloroform is pure. But subsequent experience has shown[2] that the small quantity of alcohol which is usually added to chloroform is quite sufficient to change the colour of the permanganate, so that Yvon's test can hardly be depended upon.

Now that there are several reliable manufacturers of chloroform for anæsthetic purposes, the difficulty of obtaining a pure drug is far less than it formerly was. But the purest chloroform is liable to decomposition. Exposure to sunlight and air will, in the course of a short time, lead to the formation of **carbonyl chloride,**[3] as has lately been shown by Prof. W. Ramsay.[4] This observer states that he has found carbonyl chloride in many specimens of chloroform submitted to him for analysis, and that it may be detected, on adding baryta solution to the chloroform, by a white film making its appearance at the junction of the two liquids. Prof. W. Ramsay has also found traces of **hydrochloric acid** in some samples. This acid and free **chlorine** have for several years been known to be present in chloroform which has undergone decomposition; and are to be detected by the chloroform reddening blue litmus paper and forming a precipitate with argentic nitrate. **Acetic acid** (to be detected by the process described on p. 5), **formic acid,** and **aldehyde** are also stated by Kappeler to be produced by tho decomposition of chloroform. The detection of **alcohol** is best effected by making a watery extract of the chloroform, and obtaining the iodoform reaction (p. 4). According to Kappeler, alcohol may also be conveniently recognised by the turbidity which results when equal parts of oil of almonds and chloroform are shaken together, or by the coagulation which takes place in white of egg when a few drops of the chloroform are added, or by the milky appearance which drops of chloroform assume when allowed to fall through distilled water.[1] When alcohol is present in excess of that quantity which is customarily added, the sp. gr. of the chloroform will, as already mentioned, be lower than 1.49. Alcohol, as well as other easily oxidisable substances, will, if present in chloroform, cause a cold solution of potassium bichromate acidulated with dilute sulphuric acid to turn green. Should **ether** be present it would, like alcohol, lower the sp. gr. of the chloroform. It may, moreover, be detected by dropping a watery solution of iodine into the chloroform. Should the drops remain of an amethyst colour and transparent, the chloroform is pure, but should the drops assume a dark red colour, ether is present. Crystals of nitro-sodic sulphide of iron are insoluble in pure chloroform, but dissolve in the presence of ether or alcohol. Should **methyl compounds** be present they may be detected by the chloroform becoming dark coloured or black when treated with concentrated sulphuric acid, or by a black oily layer forming when the chloroform is treated with chloride of zinc (Kappeler). According to Roussin[2] pure chloroform shaken with di-nitrosulphide of iron remains colourless; but if it contains alcohol, ether, or wood spirit, it acquires a dark colour. Kappeler,[3] referring to this test, also states that the reaction is not only caused by the presence of ethylic alcohol and ether, but by aldehyde and amylic alcohol. According to Roscoe and Schorlemmer pure chloroform does not attack bright metallic sodium, even at the boiling-point. Should the metal become coated with a white coating of chloride the presence of chlorine compounds, such as **dichlorethane** or **ethylene dichloride**, may be presumed. As a corroborative test of the presence of these impurities, these authors state that the chloroform when heated with alcoholic potash evolves the combustible gas ethylene. In one of the 101 fatal chloroform administrations collected by Kappeler, **allyl chloride** was discovered in the chloroform, but the same chloroform had been used without bad effects in other cases. In another of these cases "higher combinations of chlorine" were found in the chloroform. But in nine of the fatal cases in which the chloroform used was examined no impurity was detected.

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[1] *Pharm. Journ. and Trans.*, 1882, p. 711.

[2] *Ibid.*, 1882, pp. 740 and 769.

[3] An interesting article appears in the *Practitioner*, vol. 42, p. 418, entitled 'On a Danger attending the Administration of Chloroform by Gas-light.' The author, Dr. D. R. Patterson of Cardiff, draws attention to the fact previously pointed out by Langenbeck, that chloroform vapour may be decomposed into carbonyl chloride or phosgene gas by the action of gas-light. According to Dr. Patterson the reaction is as follows:—$2CHCl_3 + O_2 = 2COCl_2 + 2HCl$, both phosgene and hydrochloric acid gases being formed, and the former again splitting up into CO_2 and HCl. He states that Zweifel has met with pulmonary complications after chloroform used in abdominal sections by gas-light, and attributes such complications to the action of the irritating products of decomposed chloroform. Dr. Patterson found that paroxysmal cough, throat-irritation, and headache followed the use of chloroform in the neighbourhood of gas-light in a badly ventilated room.

[4] *Journ. Brit. Dent. Assoc.*, Sept. 1892, p. 629.

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[1] Kappeler, *op. cit.*

[2] Watts's 'Dictionary of Chemistry': 'Chloroform.'

[3] *Op. cit.*

Quite recently Professor Pictet has introduced a method of purifying chloroform by crystallisation. The chloroform is first subjected to a moderate degree of cold, in order to remove water and other easily crystallisable bodies. Intense cold is then applied and the chloroform crystallises, leaving a mother-liquor which is stated to retain any impurities that may have been present. The crystallised chloroform is then allowed to liquefy.[1]

Chloroform should always be kept in a cool, dark place, and in accurately stoppered bottles. As it is now an established fact that exposure to light and air is liable to set up decomposition, chloroform should certainly be obtained in small rather than large bottles, in order to lessen the chances of such decomposition taking place.

D. ETHYL BROMIDE.

Ethyl bromide, bromide of ethyl, hydrobromic or bromhydric ether, C_2H_5Br, was first prepared by Serullas in 1827. It is a transparent, colourless, highly volatile liquid, of a strong sweetish ethereal odour and pungent taste. It has a sp. gr. of 1.4189 at 15° C. (Mendelejeff), and of 1.4733 at 0° C. (Pierre). Its vapour density, according to Marchand, is 3.754. It boils at 40°.7 C., when the barometer stands at 757 mm. (Pierre). It is sparingly soluble in water, but mixes in all proportions with alcohol and ether. It burns, when ignited, with a green smokeless flame, bromine vapour being evolved. When exposed for some time to air ethyl bromide decomposes and bromine is liberated.

E. ETHIDENE DICHLORIDE.

Ethilidene chloride, dichlorethane, or, as it is more commonly called, ethidene dichloride, was discovered by Regnault, who, from the mode of its preparation, gave it the name of monochlorinated chloride of ethyl. Snow was the first to use ethidene dichloride as a general anæsthetic.[2] It has a chemical formula of $C_2H_4Cl_2$, that is to say, it is isomeric with ethylene dichloride, or Dutch liquid. Ethidene dichloride is a transparent colourless liquid, resembling chloroform in taste and odour. According to Watts its sp. gr. is 1.189 at 4°.3 C. (Geuther); according to Roscoe and Schorlemmer, 1.2044 at 0° C. (Thorpe). The boiling-point of the purest samples has been found to be 60° C. (Beilstein and Krämer), four degrees lower than the boiling-point of the substance originally prepared and studied by Regnault. The vapour density of ethilidene chloride is 49.54.[1] It is distinguished from ethylene dichloride by its behaviour with cold alcoholic potash, which decomposes Dutch liquid but has little or no effect upon ethilidene chloride. It is soluble in alcohol and ether, but is insoluble in water.

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[1] See *Lancet*, December 19, 1891, p. 1415, and *Brit. Med. Journ.*, January 23, 1892, p. 209. In the latter journal, Dr. Réné du Bois-Reymond gives an account of "the toxic action of impure chloroform."

[2] The reader is referred to Snow's interesting article on 'Monochlorurretted Chloride of Ethyle.' *Op. cit.*, p. 420.

Clover found[2] that the ethidene dichloride supplied for anæsthetic purposes had not a uniform boiling-point, but could be divided, by fractional distillation, into two or more substances. That which he used had a sp. gr. of '1225,' and a boiling-point of 46°.1, the temperature rising to 60°, at which point it boiled steadily till it was nearly all dissipated.

F. AMYLENE. PENTAL.

Amylene, C_5H_{10}, was discovered by Balard in 1844, and first used as an anæsthetic by Snow. According to the latter authority, whose views have since been endorsed by all leading chemists, amylene is not a very definite compound, but a mixture of several isomeric bodies.[3]

Amylene is a colourless, thin, and very volatile liquid. Although not pungent when inhaled, its vapour has a disagreeable odour, somewhat resembling that of wood spirit. The liquid is almost without taste. The sp. gr. of amylene is stated to be .66277 at 0° C., or .6544 at 10° C. (Watts).[4] The sp. gr. of the amylene used by Snow was .659 at 56° F. The boiling-point of amylene differs in different samples, and is not constant in the same sample. Balard placed it at 39° C.; Frankland at 35° C.; and Kékulé at 42° C. The vapour of amylene is inflammable.

At about the time of Snow's death, Duroy is said[5] to have carefully studied the boiling-point of amylene, and to have found that it varied widely—from 30° C. to 62° C. He found, moreover, that pure iso-amylene had a constant boiling-point of 38° C. (according to other observers, 35°). The name 'pental' is applied to a pure form of amylene introduced into commerce by Mering, and now used, more especially by dental surgeons, in Germany.

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[1] For further information see 'Watts's Dictionary of Chemistry,' vol. vii., 2nd Supp., 1875, p. 490.

[2] *Brit. Med. Journ.*, May 29, 1880, p. 797.

[3] See Roscoe and Schorlemmer, vol. iii. pp. 240 and 283. Also Watts's 'Dictionary of Chemistry,' 3rd Supp., vol. viii. pt. 1, 1879, p. 79.

[4] See *Ann. Ch. Pharm.*, 4th Supp., 143.

[5] See *Brit. Journ. Dent. Science*, June 1, 1892, in which an abstract of a paper on 'Pental' from the *Vierteljahrsschrift für Zahnheilkunde* appears. The paper is by Dr. Julius Kossa and Herm. Neumann of Budapest.

CHAPTER II.

THE GENERAL CONDITION OF THE PATIENT.

A. SEX AND AGE.

Sex.—Sex has a distinct, though probably only an indirect, influence upon the effects produced by general anæsthetics. Taken as a class, women certainly pass very easily into deep anæsthesia—a fact which may be explained by their physique being, as a rule, inferior to that of men (*vide infra:* D.). At the extremes of life, *i.e.*, when differences in muscular development are very slight, the influence of sex is barely perceptible. Moreover, men with feebly developed muscular systems take anæsthetics very much in the same manner as women. Emotional disturbances at the very outset of or after the administration are, however, commoner in women than in men.[1]

Age.—The age of the patient has of itself no special influence in modifying the effects produced by anæsthetics. It is rather the presence, at different periods of life, of different physical and other conditions which must be considered. The use of chloroform, for example, for patients between certain ages and of ether for patients at other periods of life cannot be regarded as rational. The selection of the anæsthetic, as will be presently shown, must be regulated more by the physical condition and temperament of the patient, and the nature and length of the operation, than by age. General anæsthetics may be given to patients of all ages. Infants but a few hours old may be safely anæsthetised; and anæsthetics have been successfully administered to centenarians.

The upper air-passages of **infants and very young children** are so sensitive that ether often causes some irritation and respiratory difficulty. This has led many to prefer chloroform, which is certainly inhaled with comparative ease by children. It is a mistake to suppose that children are not as susceptible as adults to the toxic effects of chloroform, and that with them fatalities are practically unknown. It is true that children inhale chloroform freely, and that they are not as prone as adults to alterations in the rhythm of breathing. It is probable also that children may be rescued from conditions of respiratory and circulatory depression which in adults would be attended by more immediate risk to life. But children are occasionally placed in considerable peril by chloroform, and more fatalities under this anæsthetic have been recorded than might be imagined.[1] Although chloroform is apparently better borne than ether by children, it nevertheless possesses certain special disadvantages in these subjects. It not infrequently induces an extremely tranquil and sleep-like respiration which deprives the administrator of the most important means of knowing how deeply his little patient is anæsthetised. This reason is alone sufficient to warrant us in the use of ether in some form or another for very young subjects. When ether is properly and carefully given to infants they take it far better than is generally believed. A Skinner's mask (Fig. 40), or some similar open inhaler[2] should be used, and plenty of air given (see Illustrative Case, No. 10, p. 174). The A. C. E. mixture answers well in infants; and, when the operation is likely to be of some duration, is more appropriate than ether itself. For children of two or three years of age the best plan is to commence with a small quantity of this mixture, till the crying, which is almost inevitable, has nearly subsided, and then to proceed with ether from a Clover's Portable Regulating Inhaler (Fig. 28, p. 139), the indicator of which should be placed about half-way between '0' and '1.' If a little care be taken not to give too strong a vapour of ether, and not to keep the inhaler applied for more than a few moments at a time, it will be found that respiration, though moist, quickened, and noisy, will not become nearly so embarrassed as when these simple precautions are not observed. Mucus is often produced in considerable quantities; but this need cause no anxiety to the administrator. Ether inhalers in which it is difficult or impossible to regulate the strength of vapour to the requirements of the case are not so suitable for anæsthetising very young children. If the little patient be a trifle older (four to seven years), and sufficiently tractable and intelligent to breathe through a face-piece, the best plan is to administer a small quantity of nitrous oxide and to change the nitrous oxide face-piece for that of a Clover's or Ormsby's inhaler previously charged. This plan has the great advantage that all crying and struggling are prevented—often a point of some importance—for if the administrator can coax his little patient to take but three or four breaths of nitrous oxide, anæsthesia will immediately ensue.

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[1] See p. 215. Of the 210 chloroform fatalities referred to, only 59 or 60 occurred in females.

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[1] Comte, who has collected records of 232 chloroform fatalities, found that, of this number, 21 occurred in children.

[2] Mr. Woodhouse Braine administers ether to children, and with the best results. He employs small cones made of lint, and drops the ether upon the lint. I have often followed this practice, and believe that, when care is taken, there is very little if any risk of bronchitis supervening. The youngest patient I have thus anæsthetised was fourteen days old, and the operation was circumcision.

Patients advanced in years often take anæsthetics better than middle-aged, or more vigorous subjects. They are less prone to muscular spasm: they usually require smaller quantities of the drug employed to produce desired effects: and, by reason of the frequency with which their teeth are defective, an oral air-way is more readily available for respiratory purposes. Ether may be given to old people with perfect success and safety if the respiratory functions have not become seriously impaired by senile or other changes. It is best, as a rule, to precede ether by a small quantity of the A. C. E. mixture (see p. 256); and air-limitation should not be practised too freely. Nitrous oxide followed by ether is not so satisfactory as the succession of anæsthetics here recommended. It must be remembered that ether produces a deeper and more rapid respiration than chloroform or its mixtures, and it sometimes happens, when etherising old people, that the respiratory apparatus finds some difficulty in meeting the demands made upon it. When the respiration, by reason of degenerative changes within the lungs and chest walls, has become more abdominal than thoracic; when much emphysema or chronic bronchitis is present; or when there is considerable obesity, with shortness of breath and indications of rather defective blood oxygenation; ether may cause difficulties in breathing. In these cases the A. C. E. mixture is a most valuable anæsthetic, and is very satisfactorily borne by aged subjects who do not take ether comfortably. A few cases, however, will be met with in which chloroform should be given in order to secure tranquil anæsthesia. Nitrous oxide may be administered to very elderly people, but care must be exercised. The gas should not be pushed quite as far as in younger subjects, otherwise, when the inhaler is removed, respiration may not recover itself as quickly as is desirable.[1] The use of oxygen with nitrous oxide is specially indicated in senile subjects (see p. 69).

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[1] Mr. Braine and Mr. Bailey have given nitrous oxide to patients over 90 years of age.

B. TEMPERAMENT.

Patients of a **placid and equable** temperament are, as a rule, somewhat easier to anæsthetise than **excitable, highly-strung,** and **neurotic** persons. Nitrous oxide is an excellent anæsthetic for patients of the latter class, for by its means excitement—at all events during the administration—may be abolished. When longer anæsthesia is required, nitrous oxide may be followed by ether with the best results. Reflex actions are, for the most part, more marked and more difficult to subdue in neurotic and hysterical persons than in those of a non-excitable temperament. Muscular rigidity is sometimes a troublesome phenomenon in the former subjects; and, when very sensitive parts are being operated upon or manipulated, there is often a tendency, even during deep anæsthesia, for slight movement or other reflex effect to manifest itself. Screaming, sobbing, and other emotional disturbances, during recovery from the effects of the anæsthetic, are much more common in hysterical and nervous persons than in those of an opposite temperament.

C. HABITS OF LIFE.

Those whose nervous systems have become undermined by **alcoholic indulgence,** the **morphia habit,** the excessive use of **tobacco, chloral,** or **other narcotics,** will often be found to require very considerable quantities of the anæsthetic before complete relaxation occurs. I have had, for example. to administer 5½ ounces of chloroform, in 1¼ hours, to an alcoholic man of fifty-six. It is occasionally difficult, if not impossible, to secure total muscular relaxation in certain patients of this class, and reflex movements during operations upon sensitive parts may obstinately persist, even though dangerously large quantities of the anæsthetic be administered. In confirmed alcoholics the stage of muscular excitement is usually prolonged, and, at all events with chloroform, there is need for caution during the rigidity and irregular respiration (see p. 203). Dr. Sheppard states in his notes[1] that recovery from anæsthesia is often abrupt in alcoholic patients, which is quite in accordance with what I have observed. Past alcoholic indulgence may, after months or years, show itself in the behaviour of the patient under the anæsthetic. The excessive use of tobacco may lead to an irritable condition of the pharynx and larynx, and to troublesome coughing during administration.

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[1] See Preface.

Patients should not be allowed to smoke immediately before an anæsthetic is given.

Persons who have **frequently taken anæsthetics** become less and less susceptible to their influence as time goes on, and require much larger doses, so to speak, than were at one time necessary. I have given gas-and-ether, chloroform, and nitrous oxide (on different occasions) to a patient who had been anæsthetised between thirty and forty times before, and on each occasion I had to press the anæsthetic to a much further extent than is usual, in order to obtain tranquillity during operation.

High living, more especially if associated with want of exercise, leads to obesity, plethora, and other conditions, which, as will be presently shown, are capable of materially modifying the effects of anæsthetics (see p. 20).

D. GENERAL PHYSIQUE.

The phenomena which attend the administration of an anæsthetic will be found to depend, to a very considerable extent, upon the general physique of the patient. Experience enables us to predict, from the appearance presented by the patient, the manner in which the anæsthetic will be taken. Patients who belong to the same type usually exhibit very similar phenomena during the induction and maintenance of anæsthesia, always provided that the circumstances (such as the anæsthetic employed, the nature of the operation, the time after food, &c.) are the same. Moreover, persons of one type will behave very differently from those of another type, the circumstances as before remaining the same. It is a remarkable fact that the patient whose health has become somewhat impaired by disease is a better subject for an anæsthetic than the patient of healthy appearance and good general physique. For reasons to be subsequently discussed, this observation applies more particularly to chloroform. The **healthy, vigorous, and stalwart** adult is by no means always the best subject for an anæsthetic. It is true that his respiration and circulation will hold out longer under any strain imposed upon them than the respiration and circulation of a feebler person; and in this he is, of course, at an advantage. But he does not pass so easily into anæsthesia as a weaker and more **fragile** patient. This would seem to be principally due to the stage of excitement being more marked, and to muscular spasm, interfering with respiration, being more pronounced than in feeble subjects. The amount of anæsthetic needed to produce sleep will be found to vary very considerably with the general physique of the patient. For example, a man of six feet in robust health may require from eight to ten gallons, or possibly more, of nitrous oxide, before he is completely anæsthetised; whereas an ill-nourished young woman of short stature may exhibit all the signs of complete anæsthesia from this gas after inhaling from two to three gallons. Emaciated children require remarkably small doses of an anæsthetic. Should the patient possess a thick beard or moustache some delay may arise, when employing nitrous oxide or ether, by reason of the difficulty of preventing air from gaining admission by the sides of the face-piece.

Patients who are the subjects of extreme **obesity** usually exhibit phenomena differing somewhat from those met with in thin and spare individuals. As a general rule they are intolerant of any anæsthetic which, by reason of the method of administration employed, limits the supply of air to any considerable extent. The A. C. E. mixture and chloroform are therefore usually better borne by such subjects than nitrous oxide or ether; although if care be taken the last-named anæsthetic may often be used with success. It is advisable to avoid, as much as possible, all hindrance to free respiration during the use of anæsthetics in these subjects.

Patients with a **florid colour**, as well as those who are distinctly **plethoric**, require more of an anæsthetic than anæmic and sallow persons. For reasons which I have elsewhere[1] given in detail, respiration is more likely to become hampered in full-blooded patients than in those of an opposite type. It is sufficient to say, in the present place, that the parts constituting the boundaries of the upper air-passages may, in vascular subjects, become so engorged as to lessen the capacity of those passages. This vascular turgescence and consequent swelling is most pronounced under nitrous oxide or ether, but may also be observed under other anæsthetics, and appears to be often partly dependent upon the degree to which air-limitation is allowed to occur during the administration. The tongue of a plethoric, short-necked patient under nitrous oxide may, for example, become noticeably increased in size. The so-called 'falling back of the tongue' is often partly or wholly the outcome of an increased size of that organ. Mucus and saliva are usually freely secreted during the administration of ether to young patients, more especially young women of good colour. When the face of the patient is very florid it will rapidly become dusky or cyanosed, should the air-supply be purposely or accidentally restricted. Thus, under nitrous oxide or ether, red-faced patients assume an appearance which to the onlooker might cause alarm; moderate duskiness of the features is not of itself indicative of any untoward condition in such cases. As a general rule, florid vascular subjects should be kept deeply anæsthetised; for if only moderate anæsthesia be secured, inconvenient reflex actions will be found liable to result.

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[1] See 'Clinical Observations upon Respiration during Anæsthesia; with Special Reference to the Causes of Embarrassed and Obstructed Breathing' (*Trans. Roy. Med. Chi. Soc.*, vol. lxxiv. 1891, p. 107).

Anæmic patients take anæsthetics very well, small quantities being required to secure tranquil anæsthesia. It would seem that in these subjects there is not that need for maintaining very deep narcosis which undoubtedly exists in the case of florid and healthier persons. Should any indications of restlessness or spasm arise, a very little more of the anæsthetic will subdue them. The small quantity of the anæsthetic required usually allows of a speedy return to consciousness—a fact well exemplified in the case of nitrous oxide. With this gas the available anæsthesia (*i.e.*, the anæsthesia which remains after the removal of the face-piece) is of very short duration in anæmic patients. Air-limitation should be practised as little as possible with these subjects, for they are intolerant of any asphyxial state. Nitrous oxide mixed with oxygen is hence a better anæsthetic than the former gas alone. In cachectic and very feeble persons undergoing rather formidable operations it is usually best to secure a fairly deep anæsthesia for the *commencement* of the operation, and then to allow the patient to pass into a condition of light anæsthesia for the *remainder* of the time (see Illust. Case, No. 34, p. 316).

Certain phenomena during the use of anæsthetics will be found to be dependent upon the manner in which the **teeth** of the lower jaw engage those of the upper. The patient whose upper and lower teeth meet accurately, will be liable to exhibit a greater tendency to hampered breathing than the patient whose teeth are more or less defective. Moreover, should the upper and lower teeth engage one another in such a manner as to render it difficult to move the lower jaw upon the upper, greater embarrassment in breathing will be likely to arise than under other circumstances (see p. 290). Should the patient be wholly **edentulous** it may be necessary to keep the gums and lips apart, in order to maintain respiration. **Fixity or lessened mobility of the lower jaw**, from disease of its articulations (see Illust. Case, No. 31, p. 295), local inflammatory conditions, or from the presence in the sub-maxillary or cervical regions of glandular or other tumours (see Illust. Case, No. 28, p. 293), may also give rise to difficulties in breathing. The nature and causes of the difficulties will be fully considered later on.

E. THE CONDITION OF THE RESPIRATION.

The manner in which respiration takes place prior to the use of an anæsthetic will influence the phenomena of the administration. It must be remembered that, when consciousness has been destroyed, any pre-existing tendency to embarrassed breathing is likely to become increased. When any such tendency is present it is, therefore, well to ascertain its nature and degree.

The State of the Upper Air-passages.—A few words may be said concerning the state of the upper air-passages. If the nasal air-way be free, breathing will usually take place either partly or wholly through it during anæsthetic sleep. If it be more or less obstructed the anæsthetist may be obliged to keep open an oral air-way by the use of some form of mouth-prop (Fig. 3, p. 82). Partial **nasal obstruction** will tend to become complete. Even though the nasal passages be free some patients do not breathe through them when deeply anæsthetised, from which it follows that the state of the teeth becomes of interest, if not of importance. If no teeth have been lost, oral breathing will, during the masseteric spasm of incipient anæsthesia, become obstructed. The preliminary insertion of a little mouth-gag between the teeth of those patients whose breathing is likely to become thus obstructed will serve to avoid difficulties. Temporary hindrances to breathing from the causes here indicated are most liable to arise in vigorous young subjects.

Morbid growths of the tongue, soft palate, tonsils, pharynx, epiglottis, and adjacent parts may, from vascular turgescence or alteration in position, interfere with free respiration during anæsthesia. Any deprivation of oxygen is especially liable to lead to this increase in size. Patients with enlarged tonsils will be found, for example, to take nitrous oxide with oxygen (see p. 119) far better than nitrous oxide administered in the ordinary manner, *i.e.*, without any oxygen. With the former method respiration at most becomes snoring; whereas, when nitrous oxide free from oxygen is fully administered to a patient with very large tonsils, embarrassed and obstructed respiration (usually only temporary) will result.[1] Glandular, lipomatous, and other **tumours of the neck**, including **thyroid growths**, may, during vascular engorgement, seriously lessen the capacity of the air-way and thus favour obstructed breathing.[2] Should the patient whose air-way has become narrowed suffer from even occasional or slight difficulty in breathing, the advisability of preliminary tracheotomy should be discussed.

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[1] Mr. Bailey (*Brit. Med. Journ.*, March 29, 1884, p. 645) refers to a case of carcinoma of the tonsils in which respiration ceased (probably in the manner suggested in the text). Tracheotomy became necessary.

[2] See a case, *Lancet*, September 1, 1888, p. 442, and *Brit. Med. Journ.*, September 15, 1888, p. 625. Also *Brit. Med. Journ.*, October 29, 1892, p. 964.

When **dyspnœa from laryngeal disease, narrowing of the trachea, or similar conditions,** is present great care must be exercised. When the dyspnœa is considerable, the patient somewhat cyanosed and unable to lie down, and sleep is hardly possible, the risks of giving a general anæsthetic are great.[1] Extraordinary muscles of respiration are brought into play, and when these muscles are thrown out of action during unconsciousness, and the respiration is left to the care of a mechanism which is only efficient under normal or slightly abnormal conditions, failure of breathing is liable to arise. Cases of enlarged thyroid, thoracic aneurysm, and diphtheritic inflammation of the larynx come under this head, and are deserving of very careful consideration before the risks of inducing artificial sleep are encountered. The question as to the desirability of giving an anæsthetic to such patients would necessarily be much influenced by the possibility of performing tracheotomy should respiratory difficulties arise. Should the affection causing the dyspnœa be situated so far down the trachea that this measure could not be resorted to, the risks of anæsthesia become very considerable.[2] In patients suffering from dyspnœa due to an enlarged thyroid gland, as indeed in all patients suffering from dyspnœa due to a much constricted air-way, chloroform or the A. C. E. mixture is to be preferred to ether. Should the dyspnœa be due to nerve-irritation it will diminish during deep anæsthesia, and as in the case reported on p. 239 (Illust. Case, No. 14), no special trouble will be experienced. But should the difficult breathing be due to local pressure, this improvement in symptoms is not to be looked for, and tracheotomy, if possible, may become necessary.

Bronchial, Pulmonary, and Pleural Diseases.—Should the affection be but slight, and of a chronic character, ether may, in most cases, be advantageously chosen. Ether is often said to be wholly contra-indicated in these cases; but if given cautiously, slowly, and with a proper supply of air, it answers well. The respiratory difficulties which sometimes attend the use of ether in patients suffering from pleural or pulmonary affections are frequently more apparent than real. This anæsthetic, indeed, by maintaining a rather exaggerated form of breathing and a somewhat excited circulation, is particularly suitable for many cases which at first sight might seem to contra-indicate its employment

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[1] Mr. Jacobson ('The Operations of Surgery,' 1st edition, p. 382) holds this view.

[2] See a case which I reported in the *Practitioner*, vol. xxxix. 1887, p. 101; see also *Brit. Med. Journ.*, February 24, 1883, p. 351.

(see Illust. Case, No. 8, p. 174). Should ether be badly borne, the A. C. E. mixture or chloroform should be substituted. So far as the use of anæsthetics is concerned, old-standing lung or pleural affections are of less importance than those more recently acquired. In the former the respiratory mechanism has, by constant use, become adapted to circumstances; whilst in the latter such adaptation is in process of establishment. Patients with **chronic bronchitis, marked emphysema, chronic phthisis, old pleural disease**, and similar conditions hence take anæsthetics well when care is exercised. It is not uncommon for ether to cause, in asthmatic subjects and in those who are suffering from the affections now under consideration, a peculiar form of respiration characterised by prolonged expiratory efforts and by a variable degree of cyanosis. Should such symptoms arise during etherisation they may be very quickly relieved by changing to the A. C. E. mixture or chloroform. Nitrous oxide may be safely used in persons with chronic lung affections, but should not be pushed, perhaps, quite as far as in healthier subjects. When mixed with oxygen the anæsthesia is of a more satisfactory nature than when the gas alone is given. Should the bronchial, pulmonary, or pleural affection under which the patient is labouring be of recent origin and of sufficient intensity to cause distress in breathing, much caution must be exercised and a deep anæsthesia avoided. It is hardly necessary to point out that the greater the embarrassment to respiration before the administration, the more careful should the administrator be to allow of a copious supply of air and prevent all conditions likely to impede breathing during the use of the anæsthetic. The most difficult cases to manage are those in which respiratory embarrassment from **recent pleurisy or pleuro-pneumonia** co-exists with impaired cardiac action. When the patient is slightly dusky, his temperature elevated, his breathing quick, and his pulse accelerated and sharp under the finger, the use of an anæsthetic is attended by considerable risk. This risk is greater in patients with previously fatty and dilated hearts than in others. Numerous deaths have in fact occurred in such subjects from syncope during or immediately after transient struggling.[1]

Wholly Thoracic or wholly Abdominal Respiration.—There are various conditions which may give rise to wholly thoracic or wholly abdominal respiration. The former is most frequently met with as the result of peritonitis, or of extreme abdominal distension from intestinal obstruction, ascites, ovarian disease, &c. The latter is most commonly due to advanced emphysema or other affections of the lungs or pleuræ. Should the breathing be wholly thoracic or abdominal, the administrator will, of course, meet with more exaggerated respiratory movement than usual. If a patient should, from some acute condition, be obliged to use his thorax or abdomen only, and if the new form of respiration should be somewhat difficult for him to acquire by reason of pre-existing conditions, such as emphysema or obesity, anæsthetics must be used with caution. Should the abdomen be greatly distended from ascitic fluid, a light anæsthesia only is necessary during its removal (see Illust. Case, No. 17, p. 247), and the administrator will find that both respiration and circulation will markedly improve as the fluid is evacuated and the lungs become able to expand more freely.

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[1] A typical example will be found in the *Brit. Med. Journ.*, I. 1881, p. 385. Ethidene dichloride was being used; the fatal syncope took place when the patient was turned on to his sound side. At the post-mortem the right heart was full and the left empty.

F. THE CONDITION OF THE CIRCULATION.

The circulation of the patient may be of the most efficient type; or it may be so feeble as to render it questionable whether any operation should be performed. The pulse may be so rapid that it can hardly be counted; or, on the other hand, it may be abnormally slow. When mental emotion is the cause of the quickening, a considerable slowing will invariably occur during anæsthesia; but when the rapid pulse is due to shock, exhaustion, &c., an increase in rate will usually be found to occur (see Illustrative Case, No. 34, p. 316). I once gave an anæsthetic to a patient, an elderly gentleman, whose pulse was usually 28 to 30 per minute.[1] A very slow pulse is often met with in patients suffering from cerebral disease. Patients whose heart's action is good and whose pulse is full and strong, will be better able to withstand any unwonted cardiac strain (as, for example, that incidental to any embarrassment of respiration) than patients of less vigorous circulation (see Illustrative Case, No. 31, p. 295).

Valvular and other Cardiac Affections.—Patients with these affections may be anæsthetised with safety if care be taken to select the anæsthetic most appropriate to the case, and to administer it in such a manner that no undue strain is thrown upon the heart. Where the cardiac affection is but slight, and, by reason of compensatory changes, the general circulation is good, little or no alteration need be made in the anæsthetist's usual practice.

There are one or two points, however, which should be borne in mind in dealing with **advanced cases.** Unless orthopnœa exists, the recumbent, or semi-recumbent position should be enforced; no marked or prolonged deprivation of oxygen should be permitted; and any interference with respiratory rhythm should be prevented. The anæsthesia of nitrous oxide followed by ether, for reasons to be subsequently described (see p. 70), is not to be recommended in these cases. All methods of administration should be gradually conducted, and the behaviour of the circulation narrowly observed. Speaking generally, the A. C. E. mixture is an excellent anæsthetic for patients with advanced morbus cordis (see Illustrative Cases, Nos. 19, 20, 21, and 22, pp. 248 and 249). It may be administered in all forms of valvular disease, and is remarkably well borne. Ether (preceded by a small quantity of the A. C. E. mixture to prevent its disagreeable odour) may be used in cases in which there is no evidence of **great pulmonary or systemic engorgement.** It would also appear to be desirable to employ ether, or, at all events, to attempt its exhibition in those cases in which **orthopnœa** is present. Such patients, fortunately, rarely require anæsthetics; but, owing to the position which they are bound to assume, chloroform and its mixtures should be avoided if possible (see Illustrative Case, No. 9, p. 174). By the gradual administration of the A. C. E. mixture to a patient with an intermittent or irregular pulse, the heart's action always becomes steadier, and remains so for a considerable time. The anæsthetist must not, however, shut his eyes to the fact that after the withdrawal of the anæsthetic, or during a serious operation, this improvement may, and often does, become replaced by irregularity and feebleness in excess of the original condition.

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[1] This case is referred to on p. 161.

Atheroma.—In extremely atheromatous subjects there is a slight risk[1] of cerebral hæmorrhage during anæsthesia. This risk may, however, be minimised by selecting the A. C. E. mixture or chloroform in preference to ether; and by avoiding, as far as possible, excitement, holding of breath, coughing, and struggling during the administration. In order to do this the anæsthetist must proceed very gradually with the inhalation, and by a little management he will usually succeed in getting a patient of this type to pass into a state of quiet anæsthesia with little or no trouble. Should arterial degeneration have led to the formation of an **aneurysm** the same caution as to the avoidance of struggling, straining, coughing, &c., should be exercised. It is true that ether has very frequently been given to patients with large aneurysms without rupture having occurred, either during the induction of anæsthesia or during complete narcosis; but when there is any evidence of rapid increase in size, and more particularly when the aneurysm is intra-thoracic, the A. C. E. mixture or chloroform should be used in preference to ether.

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[1] See a case which occurred in the practice of Dr. Fuller of Montreal, reported in *Canadian Med. and Surg. Journ.*, March 1888, p. 309, and referred to in Dr. Turnbull's 3rd edition of 'Artificial Anæsthesia,' p. 252.

Exhaustion. Collapse.—One is often called upon, more particularly in hospital practice, to anæsthetise patients whose circulation has become much enfeebled, either from some long-standing disease, or from some recently acquired but prostrating malady. As illustrations may be mentioned:—cases of hip disease and hectic in children, cases of stricture of the pylorus necessitating gastrostomy, cases of strangulated hernia, and cases of collapse from railway or other injuries. Such patients are very susceptible to anæsthetics, small quantities only being necessary to induce and maintain anæsthesia. As a general rule, the pulse of the exhausted patient improves in volume when anæsthesia is established; but, directly the anæsthetic is withdrawn, some depression of the circulation may follow. Moreover, this initial improvement does not, as a rule, last long; and any loss of blood, prolonged exposure, or severe surgical procedure will soon give rise to signs of circulatory depression. Should the pulse be quick beforehand it will usually become more rapid during the administration. The administrator must do all in his power to sustain the strength of these patients. Should the heart's action be very feeble, no method of administration should be employed by which the supply of air is greatly restricted, and all mechanical or other hindrances to free respiration must be avoided. Ether is, as a rule, best administered by the open method and in small quantities at a time. Should a close inhaler be used, care must be taken to remove it frequently for the admission of air. The administration of nitrous oxide is best avoided in these cases. Patients who are much exhausted before the operation usually exhibit a peculiar condition of the eyelids soon after anæsthesia has become established. The lids lose their tone and do not close, so that the sclerotic becomes visible. When this condition is seen it usually indicates great prostration of the vital powers; but it may arise from too large a quantity of the anæsthetic having been given, or possibly from other causes. Profuse sweating is also common in these subjects, and is another indication of exhaustion. The administrator must be on his guard with reference to the rosy cheeks of **hectic subjects** and of those artificially stimulated by alcohol. This florid colour may co-exist with a circulation totally unable to withstand any very prolonged surgical interference. Patients suffering from **intestinal obstruction** are, perhaps, appropriately considered under this heading, seeing that, in extreme cases, syncope of the worst type has been known to arise during anæsthesia. The abdomen is usually distended, and the diaphragm unable to act efficiently; the stomach frequently contains fluid or semi-fluid material; the patient will be found to be, in many instances, partly under the influence of an opiate; and the circulation, though often artificially stimulated by alcohol, may be in reality utterly unable to withstand any severe strain. When the abdomen is distended and inactive, the pulse quick and feeble, the extremities clammy and dusky, the features pinched and the lids half open, general anæsthesia is, to my mind, out of the question. In less advanced cases an anæsthetic may be given; but caution is very necessary. As the question concerning the use of an anæsthetic in intestinal obstruction, peritonitis, &c., is one of great importance, I would refer the reader to Illust. Cases, No. 18 (p. 247), and No. 26 (p. 274).[1]

G. THE CONDITION OF THE NERVOUS SYSTEM.

Should the patient be **drowsy or half unconscious** at the time of operation the administrator must be careful as to his procedure. In such cases very small quantities of the anæsthetic should be given. The subjects of depressed fracture of the skull, intracranial hæmorrhage, cerebral abscess, or cerebral tumour may, at the time of operation, be so lethargic that a few inhalations of the anæsthetic will readily produce the quietude desired by the operator. The same may be said concerning patients who are more or less under the influence of an opiate at the time of the administration (see Part II. Ch. VIII.). Should well-established **coma** from any cause be present, the services of an anæsthetist will not, of course, be required. Should the patient be semi-conscious from cerebral disease, and should the operator consider it desirable to give a preliminary injection of morphine before the anæsthetic, the smallest possible quantity of the latter should be administered. The use of morphine in conjunction with general anæsthetics will, however, be fully and specially discussed in Part II. Ch. VIII.

Patients who are the subjects of chronic nervous affections may exhibit peculiar respiratory phenomena during anæsthesia. Thus, I have notes of two cases—one patient had **disseminated sclerosis**, and the other advanced **tabes dorsalis**—in which, during the use of an anæsthetic (ether), breathing was jerky, catchy, halting, and split up, as it were, by long pauses. In the ataxic patient some degree of laryngeal obstruction, with prolonged expirations, was noted, and gave me some trouble.

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[1] For further remarks on] the use] of anæsthetics in intestinal obstruction see p. 50.

The subjects of **epilepsy** may be safely anæsthetised. In some cases a more or less distinct attack occurs during the exhibition of the anæsthetic; but the epileptic symptoms invariably pass off as the administration proceeds, and no untoward results remain. I have, on one or two occasions, noticed a greater tendency than usual to tonic and clonic spasm during the administration of nitrous oxide to these subjects.[1]

H. THE PRESENCE OF RENAL DISEASE.

When advanced disease of the kidneys is present chloroform is said to be preferable to ether. But from the satisfactory manner in which patients with all forms of visceral disease pass through prolonged administrations of the latter anæsthetic, when properly given, it is questionable whether we are justified in altogether withholding ether, at all events in some form or another, because Bright's disease exists.[2]

J. MENSTRUATION. PREGNANCY. LACTATION.

It is customary not to operate upon patients during the **menstrual period**; but in cases of any urgency no hesitation need be felt in giving an anæsthetic. Whenever possible it is best to wait. This is true even in the case of nitrous oxide, for patients may erroneously attribute disturbance of the menstrual function, &c., to the anæsthetic. Hæmorrhage after tooth extraction is said to be greater during menstruation than at other times; but this is doubtful.

If an operation has to be performed during **pregnancy** an anæsthetic may unhesitatingly be given. No departure from ordinary rules is necessary during the earlier months; but during the latter period care and discretion should be exercised. The diet of the patient should be cautiously regulated in order to avoid retching or vomiting after the administration. Nitrous oxide may be given with safety till the sixth or seventh month; but after that time it is probably better not to administer this anæsthetic, or, at all events, not to administer it in such a manner as to excite clonic muscular movements. Personally I would administer nitrous oxide with oxygen to a patient in the eighth or ninth month of pregnancy, should it be necessary for her to take an anæsthetic for the extraction of a tooth; although some administrators, I believe, would employ the nitrous oxide *per se.* Chloroform, as is well known, is taken comfortably by pregnant women, when the pains of labour have to be relieved (see p. 54). But in the event of a surgical operation being decided upon during the latter months of pregnancy, I believe we should be consulting the safety of our patient best by administering a small quantity of the A. C. E. mixture, followed by ether, as directed on p. 256; or we might use this mixture throughout. Should ether produce respiratory difficulty, cough, &c., it should not be persisted in; but the mixture or chloroform should be substituted.

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[1] Mr. Woodhouse Braine has pointed out (*Med. Soc. Proc.*, vol. viii. 1885, p. 64), that there is greater risk of an epileptic attack being brought about by tooth extraction without an anæsthetic than when one is used.

[2] Mr. Lawson Tait (*Brit. Med. Journ.*, November 27, 1880, p. 845) has referred to cases in which he has observed complete cessation of the urinary flow during deep etherisation. See also *Brit. Med. Journ.*, June 1883, p. 1082. Editorial article on 'Diseases of the Kidneys with Reference to the Administration of Ether.'

The use of anæsthetics during **lactation** in no way interferes with this process.[1] Indeed, as has been pointed out,[2] there is more likelihood of lactation being arrested by the performance of an operation without, than with, an anæsthetic.

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[1] *Med. Chir. Trans.*, vol. xlvii. 1864, p. 435.

[2] *Med. Soc. Proc.*, vol. viii. 1885, p. 63.

CHAPTER III.

THE NATURE OF THE OPERATION, PROCEDURE, OR CONDITION FOR WHICH ANÆSTHESIA IS DESIRED.

GENERAL REMARKS.

Before administering an anæsthetic we should take into consideration the nature of the operation, procedure, or condition for which anæsthesia is to be induced. In the first place, although the selection of the agent to be employed should be chiefly regulated by the general state of the patient, there are certain operations which should, whenever possible, be performed under certain anæsthetics. In the next place, there is a tendency during some surgical procedures for circulation, or respiration, or both to become influenced independently of the anæsthetic; and, unless the administrator be aware of such contingencies, he may erroneously attribute the phenomena to the action of the anæsthetic he is administering. Lastly, when certain parts of the body are being manipulated or operated upon, there is need for a somewhat deeper or lighter anæsthesia, as the case may be, than is required under other circumstances.

Before proceeding to consider *seriatim* the various procedures for which a general anæsthetic may be required, I propose to refer, in general terms, to the influence which—

(1.) The position of the patient during the administration, and

(2.) The actual performance of a surgical operation

may have in modifying the usual phenomena which attend the exhibition of anæsthetics.

(1.) **The Position of the Patient during the Administration.**—This is of no small importance from the point of view of the anæsthetist. Whenever practicable the patient should lie supine with his head and shoulders very slightly raised, and with one cheek upon the pillow. The head should never be so adjusted that the chin touches the sternum; nor should it be thrown too far backwards. There are, however, many operations in which this position cannot be adopted, and some other has to be chosen to suit the requirements of the surgeon. In some positions of the head blood is liable to enter the larynx during operations within the mouth or nose. The best positions for such cases will be discussed below (A and B). Should the nature of the operation be such that the sitting or semi-recumbent position is necessary, the administrator should avoid chloroform, and if he has been using this anæsthetic whilst the patient was recumbent he should replace it by ether when the position is changed. In those operations in which shock is prone to arise, or is present, the head should be kept low throughout, and in urgent cases the legs should be raised. In those in which the prone or latero-prone position is essential, the respiration must be carefully watched, and, if possible, ether administered in preference to chloroform.[1] When any marked respiratory embarrassment pre-exists, the position of the patient during the administration becomes a matter of the greatest importance—a circumstance which will be specially considered when dealing with operations upon the interior of the thorax (*vide infra:* D).

(2.) **The Effects which may be Produced upon the Anæsthetised Patient by the Operation itself.**—The consideration of this matter belongs rather to the province of the operator than to that of the anæsthetist. But seeing that many of these effects may be prevented or modified by skilful administration, and also that it is not always easy to say what share the operation and what share the anæsthetic may have had in the production of any particular state, it is well that we should briefly discuss these effects from our present standpoint. There are various ways in which the circulation of the patient undergoing a surgical operation may become affected as the direct result of the operation itself. Profuse or protracted hæmorrhage may occur, and give rise to urgent or gradual symptoms of circulatory depression (see Illust. Cases, No. 33, p. 315, and No. 34, p. 316). Infants, very old persons, and anæmic and cachectic subjects are naturally more seriously affected by loss of blood than more vigorous persons. During the removal of large and vascular tumours, the excision of the upper jaw, and similar cases, the anæsthetist should narrowly watch the colour and pulse of the patient, and should not administer more of the anæsthetic than is absolutely necessary. The greater the quantity of blood lost, the less will be the quantity of anæsthetic required. Then we not infrequently meet with cases in which the heart's action becomes enfeebled, partly by reason of hæmorrhage, and partly also from other causes, such as the division of important nerves, the prolonged exposure of large cutaneous or cut surfaces, &c. When a large vascular growth has to be removed, or a major amputation upon a feeble subject performed, signs of circulatory depression will be liable to arise; and all the resources of the anæsthetist may be called into play. The question often arises, in such cases as the above, as to how long the operation should be allowed to continue. I have usually found that so long as the pulse can be counted at the wrist, so long may the patient be kept upon the operating-table. I am speaking now of those cases in which signs of exhaustion from loss of blood and general shock come on gradually. Should the pulse become a running pulse, or almost imperceptible, no time should be lost in removing the patient to bed. Lastly, we meet with certain cases, as important as they are interesting, in which, *independently of the anæsthetic, and independently too of hæmorrhage, or of prolonged surgical interference*, symptoms of cardiac depression, possibly of an urgent character, make their appearance. Transient reflex effects upon the heart's action at the moment an incision is made or some other procedure carried out are not uncommon, more especially during a light anæsthesia under chloroform. In most cases the effect upon the circulation is so slight that it is not noticed; or, at most, a passing pallor is seen. But more grave symptoms may result. Mr. Bickersteth of Liverpool drew attention, as far back as 1853, to certain cases in which sudden cessation of the pulse was observed to occur simultaneously with the commencement of the operation;[1] and other observers have supported his contention, having reported cases in which, more especially during operations for strabismus and tooth extraction under light anæsthesia, sudden syncope has arisen. But at the present time sufficient attention is not paid to the effects which certain surgical operations may themselves bring about upon an anæsthetised patient. I have myself on many occasions met with undoubted examples of reflex cardiac depression; and I believe that the true nature of such cases is frequently overlooked. It is highly probable that such effects may be prevented to a great extent by a very deep anæsthesia; but even this fact is not certain. It also seems that the heart's action is more likely to be permanently affected under chloroform than under nitrous oxide or ether. As it would be out of place to quote exceptional and abnormal cases before we have fully considered the more usual course taken by patients under anæsthetics for surgical operations, I must here refrain from referring in detail to those instances of this form of circulatory depression which have come under my own observation. I have, however, given these cases in subsequent portions of the book, and would refer the reader to them. In Illust. Cases, Nos. 35 (p. 316) and 41 (p. 321), the changes in the circulation came on during operations upon the kidney: in Nos. 36 (p. 317) and 40 (p. 320), during long skin incisions for the removal of the breast; in No. 37 (p. 318), during the incision for a Syme's amputation in a feeble subject; and in Nos. 38 (p. 318) and 39 (p. 319), during an operation in the neighbourhood of the vagus in the neck. It is possible that in some of the cases the patient was not quite deeply enough under the anæsthetic; but it is difficult to speak with certainty upon this point.

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[1] The late Dr. Sheppard drew special attention to this point, and his observations are of considerable interest and value (see *Brit. Med. Journ.*, July 11, 1891, p. 68: 'The Administration of Ether in Operations requiring the Lateral or Prone Positions,' by C. E. Sheppard, M.D., F.R.C.S.). Dr. Sheppard quotes Dastre (*Les Anesthesiques*, Paris, 1890, p. 92), who found that, whilst a weight of 75 kilogrammes placed upon the thorax was necessary in order to bring the respiration of a conscious dog to a standstill, only 25 kilogrammes were needed after one hour's chloroformisation. Dr. Sheppard adds: "As regards actual clinical experience, I have twice met with cases where under chloroform an absolute cessation of respiration occurred as the direct result of impeded thoracic and abdominal movement in the semi-prone position; this was at once rectified by simply replacing the patient in the supine position, and thus removing the mechanical impediment."

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[1] See *Edinburgh Monthly Journal*, 1853, vol xvii. p. 220: 'On the Mode of Death from the Inhalation of Chloroform,' by E. R. Bickersteth. After giving some very interesting experiments and clinical observations, Mr. Bickersteth says: "A peculiar and interesting fact, and one that I am inclined to think may account for many deaths, is, that in some individuals, when fully under the influence of chloroform, the pulse suddenly fails at the moment the first incision is made by the surgeon, and this, too, when the respiration is altogether natural." In support of this opinion three striking

A. OPERATIONS WITHIN OR ABOUT THE MOUTH, NOSE, PHARYNX, AND LARYNX (EXCLUDING THE EXTRACTION OF TEETH, SEPARATELY CONSIDERED).

Operations upon the Lips, Cheeks, Jaws, Tongue, Floor of the Mouth, Palate, Tonsils, Naso-pharynx, and Nose.—For these operations the patient should, as a general rule, be first placed *fully and deeply under ether.* There are necessarily cases in which this anæsthetic is contra-indicated by reason of the condition of the patient; but these do not concern us here. Ether may, whenever practicable, be preceded by nitrous oxide

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cases are quoted; in all of which, at the moment the incision for amputation of the thigh was made, the pulse suddenly ceased for several seconds. Two of the patients were markedly emaciated, and the other was probably feeble. In one of the cases the countenance became deadly pale, and breathing flagged during the cardiac depression; whilst in one of the others the respiration was unaffected, and very slight pallor was observed.

(Part II. Chap. III.), or a small quantity of the A. C. E. mixture (see Part II. Chap. VI.), but this is not essential. The operation, if of lengthy duration, should not be begun till some time after the full effects of the ether have been produced, *i.e.*, till the patient has been breathing ether vapour for several minutes. Nothing is more unsatisfactory than for the operator to commence just when deep anæsthesia has become established; for the momentary withdrawal of the anæsthetic, necessitated by the commencement of the operation, often allows the patient to 'come round' to a certain extent, and to struggle inconveniently. This will not be the case if the patient has been 'charged up,' so to speak, with a considerable quantity of ether before the operation is commenced. I have on more than one occasion, for example, given a patient, in the first instance, such a quantity of ether that the operator has been able to remove the upper jaw or tongue without any more anæsthetic being required. This charging up of the patient is not to be recommended with chloroform. In a large number of cases the initial dose of ether will obviously be insufficient, and it is then best to keep up the narcosis with chloroform, administered either by means of Junker's apparatus (Figs. 46 and 49), or upon lint. The change to chloroform should not be effected till the patient has been deeply under ether for several minutes. Should he have been breathing ether for a minute or two only, when the chloroform is applied he will certainly partially 'come round,' and the administrator, in his endeavour to keep the patient quiet, will be very liable indeed to give an overdose of chloroform. It is possible that the brisk circulation and respiration of the etherised patient favours a large intake of chloroform. This objection does not apply when ether has been given say for five or six minutes, for the quantity of chloroform then required to allay any symptoms of 'coming round' will be very small. This is an important point, applying as it does, not only to the class of cases under consideration, but to other cases in which, for some reason or another, it is thought desirable to change from ether to chloroform. The operation should be begun whilst the patient is well under ether, and as there will be no reflex movement or other response on the part of the patient, the administrator will be able to get ready to keep up the anæsthesia with chloroform. Mr. J. Mills[1] was, I believe, the first to use Junker's apparatus for keeping up chloroform anæsthesia in these cases. Before changing to chloroform the administrator should ascertain whether, in the position of the head which is most convenient to the operator, respiration takes place through the mouth or nose or both. It is obviously next to useless to insert the tube of Junker's apparatus into, or place lint sprinkled with chloroform over the mouth, when respiration is taking place through the nose; and the converse is equally true. Should the administrator wish to give chloroform through the mouth, whilst respiration is partly taking place through the nose, he should plug the anterior nares with pieces of lint and so prevent nasal breathing. When once the operation has been begun the patient should, generally speaking, be allowed to get back slight lid-reflex or other signs of only moderately deep anæsthesia; and if from the position of the head much blood is passing to the back of the throat, swallowing and coughing are to be encouraged, unless associated with inconvenient movement. Occasional phonation is admissible in protracted cases; but articulation would indicate too light an anæsthesia. Towards the end of these operations, however, when much blood has been lost, very little of the anæsthetic will be required. As a rule, the greater the hæmorrhage the lighter should be the anæsthesia. When very little hæmorrhage is anticipated the usual depth of anæsthesia should be maintained.

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[1] *Lancet*, December 14, 1878, p. 839. Mr. Mills has found, and I can corroborate his statement, that it is not always easy to keep up anæsthesia by this means in alcoholic subjects.

Success in maintaining a safe and efficient anæsthesia in these cases is very largely dependent upon the avoidance of all respiratory embarrassment from the entry of blood into the larynx. With proper management this complication may easily be avoided. It is probably the rule rather than the exception for a variable quantity of blood to gain access to the larynx during operations within the mouth and nose. But if the anæsthesia be not allowed to become too deep, most of the blood will either be carried away by the swallowing movements of the patient, or coughed back into the mouth from time to time. Should these natural efforts be absent, blood must either be repeatedly sponged out, or the head of the patient must be so placed that blood drains away. A sponge, as large as can be conveniently introduced, and unattached to any instrument, answers well in most cases.

If convenient to the operator the patient should be placed in one of three positions during these operations:—

(1.) *Somewhat upon the side, with one cheek resting upon the pillow, and so that the face is turned slightly downwards.*

(2.) *Sitting up, with the head and shoulders thrown well forwards, the face looking towards the couch or bed.*

(3.) *Supine with the head completely extended and in the mid-line.*

The first of these positions answers admirably for most jaw cases, for the removal of nasal, or naso-pharyngeal polypi, and for all operations which can be performed with the head well upon the side. The second should only be adopted under ether, and is very useful when the naso-pharynx is to be cleared of adenoid growths by means of the finger or artificial nail.[1] Should it be thought desirable, the patient may be first placed under ether whilst he is recumbent or semi-recumbent, and when properly anæsthetised he may be raised into the sitting posture and bent forward as described. The third position is used by many operators for cleft-palate operations and those for the removal of adenoid growths, &c. The naso-pharynx holds a considerable quantity of blood, and the excess flows out through the nostrils. But when nasal obstruction is present, even in a minor degree, this position is not a good one for the escape of blood. Should neither of these positions be convenient to the operator, it is the duty of the anæsthetist to maintain unembarrassed respiration and to see that blood does not accumulate at the back of the throat in quantities sufficient to obstruct breathing.

There is nothing worthy of special notice in connection with operations upon the **lips and cheek**, save perhaps that in young children anæsthesia may be satisfactorily kept up by holding the end of the tube of a Junker's inhaler a few inches away from the mouth and nose of the patient, and pumping rather vigorously. By this manœuvre the administration of the anæsthetic in no way interferes with the operator, for a sufficient percentage of chloroform vapour may thus be administered even though the anæsthetist frequently varies the position of the tube. In adults the vapour thus supplied is not of sufficient strength, and the tube must be introduced into the air-passages. I have often had recourse to the method indicated in **hare-lip** operations upon infants, and with good results.

In operation upon the **jaws** the first of the three positions above advocated is the best from the administrator's point of view, and is usually convenient to the surgeon. All blood flows into the opposite cheek; and sponging out the mouth is rarely necessary.

Owing to the varied methods of removing a portion or the whole of the **tongue**, it is difficult to lay down any special rules as to the administration of the anæsthetic. When the lingual arteries have been previously ligatured, or glands have been removed, the administration for the operation on the tongue will be easy, by reason of the patient having been under the anæsthetic for some time. When the cheek is slit up the headand turned to the opposite side, the gag shown in Figs. 52 and 53 may be used and anæsthesia kept up by Junker's apparatus, the tube of which may be inserted into the nose or mouth. When hæmorrhage is free and the lingual artery has to be secured through the mouth, the position of the head which is most suitable for the operator is not the best from the anæsthetist's point of view, so that the respiration must be watched and blood sponged away. When a considerable portion or the whole of the tongue has been removed, the breathing may become embarrassed by the stump of the tongue and epiglottis covering the opening of the larynx. Many surgeons follow the plan of passing a ligature through the base of the organ before excision, in order to avert this danger; and the anæsthetist will probably be excused in suggesting the precaution, should it have been omitted.

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[1] Mr. Woodhouse Braine first suggested this position. It certainly answers well, at all events from the anæsthetist's point of view, and is strongly recommended by Sir William Dalby.

In connection with these operations it may be well to say a few words as to the advisability of tracheotomy. Should there be any difficulty in breathing when the mouth is opened for the removal of the tongue and traction is made upon that organ, tracheotomy should be performed; for such difficulty in breathing will certainly increase during the operation.

In **staphyloraphy**, chloroform is the most convenient anæsthetic to employ. In the case of young children it is a good plan to dilute this agent with about one-fifth of its bulk of absolute alcohol. In older persons it is best to first place the patient well under ether, and then to proceed with chloroform as already described. The vascularity of the parts soon subsides, and the secretion of mucus quickly abates when the change to chloroform is effected. Junker's apparatus answers well for cleft-palate cases; though many surgeons prefer simpler means of maintaining anæsthesia. Whatever anæsthetic be used, deep narcosis should be completely established, or, preferably, should have existed for some few minutes, before the gag is inserted and the operation commenced. Care must be taken not to let the patient come round during the insertion of the gag. A somewhat lighter anæsthesia may, however, be advantageously permitted after the incisions have been made, *i.e.*, whilst hæmorrhage is taking place somewhat freely. The blood may either be removed by sponging, or the head may be turned to one side and the blood be thus allowed to escape.[1] Profound anæsthesia must now be again secured in order to avoid movement, coughing, retching, or vomiting during the insertion of the sutures. By this time hæmorrhage will to a great extent have ceased, so that there is not that objection which existed earlier in the administration to a very deep narcosis.

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[1] Mr. William Rose ('On Hare-lip and Cleft-palate,' 1891, pp. 105, 106) gives some excellent directions for the regulation of the anæsthetic. Mr. Rose advocates the use of chloroform throughout for these cases; and urges that it is best administered upon a towel drawn through a safety-pin. He objects to any nasal or buccal tubes for the administration.

I have administered anæsthetics for the **removal of the tonsils** in all possible ways, and the following I believe to be the best. The patient is placed in the semi-recumbent posture, and ether is administered till the conjunctivæ have been insensitive for some minutes. He is then propped up, almost vertically, by means of pillows; his mouth is opened by a Mason's gag; and his head adjusted so that a good view is obtained by the surgeon. These manœuvres in the sitting posture may be safely performed under ether, but are not advisable under chloroform. When the tonsils have been removed, the head should be thrown a trifle forwards, for the escape of blood; and should more ether be required, it may be given with the patient's head in this position, and the operation then completed (see Illustrative Case, No. 24, p. 257).

In operations upon the **naso-pharynx**, the position of the patient is important, owing to the free hæmorrhage which often occurs, more especially under ether. I have known large naso-pharyngeal polypi removed, and similar operations performed, without the slightest trouble whilst the patient's head has been kept upon its side, *i.e.*, in the first of the positions already referred to. The Mason's gag with the chloroform tubes (Figs. 50 and 51, pp. 199 and 200) answers well for these cases when the ether anæsthesia is of insufficient duration.

I have given anæsthetics for the removal of **post-nasal adenoid growths** with the patient—

(1.) Upon his back, the head being only slightly extended:

(2.) Upon his back, the head being completely extended:

(3.) Upon his side, the cheek resting upon the pillow:

(4.) Sitting up in a chair or on a couch, the head and body being bent well forwards: and

(5.) Sitting up in a chair, the head retaining its usual position in regard to the trunk.

Some operators prefer one position; some another. Although ether produces greater hæmorrhage, it is certainly preferable to chloroform in these cases. A single inhalation of ether will often suffice for the removal of the growths; but, when a longer anæsthesia is necessary, the unconsciousness should be kept up by chloroform administered by means of Junker's apparatus. The gag shown in Fig. 50 answers well. In the first of the five positions mentioned, the blood is best sponged away by means of a large sponge unattached to any holder, and the anæsthesia should only be deep at the moment the operation is commenced.

Should the hæmorrhage be very free, as may happen in vascular subjects under ether, the head must be turned to the side occasionally for drainage. This position is usually chosen at the Throat Hospital, Golden Square; and it is very rare for any trouble to occur from the blood entering the larynx, although this probably happens very frequently. It is a good plan to encourage an occasional cough by not keeping up too deep an anæsthesia. In the second position, there is the advantage that no blood is swallowed by the patient, so that after-vomiting is usually absent. The third position is generally considered an inconvenient one for this operation. Position No. 4 is only applicable when the growths are to be scraped away, as recommended by Sir William B. Dalby,[1] and then it answers admirably. The chief objection to the fifth position is that, should it be necessary to prolong the anæsthesia, chloroform, which is almost essential, ought not to be given with the patient sitting upright in a chair.

In all **nasal operations** it is a good plan to have the mouth slightly or widely opened by a gag, not only because of the greater ease by which a chloroform tube may, if required, be passed to the back of the throat, but because of the facility afforded for sponging away blood when necessary. I have found the gag shown in Fig. 52, p. 201, of great use in those cases in which the operator has required the patient's head to be lying in the midline. The mouth being widely opened by a gag which cannot slip, and which, therefore, need not be held by an assistant, is readily accessible for sponging out. The best results, so far as the anæsthetic is concerned, are obtained when the patient's head is upon the side; but this position is frequently inconvenient or impossible from the operator's point of view. Patients requiring operations within the nasal cavity often possess a partially or wholly occluded nasal air-way; and in such patients it is a good plan to place a little mouth-prop (Fig. 3, p. 82) between the teeth before commencing the administration. This is particularly important in muscular subjects, in whom masseteric spasm is likely to be pronounced.

Laryngotomy, Tracheotomy, and other Operations upon the Larynx and Trachea.—The administration of an anæsthetic for these operations is often a rather anxious task, because of the condition of the patient at the time. Speaking generally, chloroform, or some mixture containing chloroform, is preferable to ether. With regard to **laryngotomy and tracheotomy**, we may say that, should there be no dyspnœa, the administrator may give that anæsthetic which, by a consideration of the condition of the patient, is obviously indicated.[1] He should, if employing ether, admit as much air as possible in order to lessen venous turgescence. The selected anæsthetic, moreover, need never be pushed very far save for the first incision. When dyspnœa is present, the A. C. E. mixture or chloroform will be preferable to ether; but, as already explained, no general anæsthetic at all should be given when cyanosis and other indications of considerable embarrassment in breathing are present. For **other operations upon the larynx and trachea**, such, for example, as that for the partial or complete removal of the former organ, chloroform is undoubtedly the best anæsthetic.

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[1] 'Adenoid Growths in the Pharynx' (*Lancet*, October 1886, p. 618).

The **preliminary performance of laryngotomy or tracheotomy**, prior to the more formidable operations upon the jaws, tongue, palate, and other parts, relieves the administrator of the anæsthetic of much difficulty. This measure is strongly to be advocated whenever there exists the slightest respiratory embarrassment dependent upon the presence of the growth or disease about to be removed. Such difficulty will be liable to unexpectedly increase rather than to diminish when deep anæsthesia is present, and when the parts are being manipulated prior to their removal. I have seen this happen in connection with operations upon the tongue. There are also other circumstances under which a preliminary opening into the larynx or trachea is advisable; but these hardly come within the scope of our subject. I have seen Trendelenburg's apparatus used on many occasions, and there are just two points which may be mentioned in connection with the administration of chloroform through it. In the first place, it is better to administer chloroform from a piece of lint, or from a Skinner's mask, for some minutes after the tracheotomy tube has been inserted, rather than at once to fix on the flexible tube to the latter. In this way any blood will be more readily coughed out. When respiration has become quiet, and the colour good, the flexible tube with its expanded end for the reception of the chloroform may be attached. In the next place, it is a good plan to plug the larynx from above as an additional safeguard; for sometimes the tampon allows a small quantity of blood to gain access to the trachea. Respiration is usually considerably quicker and deeper when Trendelenburg's apparatus is used than when an ordinary tracheotomy tube is employed, owing to the greater resistance offered to the passage of air along the comparatively narrow flexible tube.

Rectal Etherisation.—This has been adopted for cases of this class, but the results have not always been as satisfactory as could be wished (see p. 172).

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[1] Mr. Durham ('System of Surgery,' vol. i. p. 771) prefers chloroform to other anæsthetics for these cases.

The Use of Morphine prior to Ether or Chloroform.—This plan is regarded by many Continental surgeons as specially advantageous in major operations within the mouth or nose, owing to the very small quantity of the anæsthetic needed to keep up anæsthesia, or, more correctly speaking, analgesia. For remarks on this mixed narcosis, see Part II. Chap. VIII. p. 271.

B. THE EXTRACTION OF TEETH.

Choice of Anæsthetics, &c.—The best anæsthetic for use in dental surgery is undoubtedly **nitrous oxide.** It is true that the resulting anæsthesia after the inhalation of this agent is of very short duration; but this disadvantage is fully compensated for by the fact that the return of the patient to consciousness is, with the rarest exceptions, unattended by those discomforts which often follow the use of other anæsthetics. This absence of after-effects is dependent upon the inhalation being necessarily short, owing to want of free oxygen. The great error which is fallen into with regard to the use of nitrous oxide in dental surgery is that too much in the way of operation is often attempted. The period of deep and true anæsthesia from nitrous oxide is short, and it is often impossible, even though the gas be freely pushed, to extract more than one tooth, without the patient indistinctly knowing something of what is going on. Our aim should be to keep the patient's mind a complete blank during the operation. Unpleasant dreams, shrieking, &c., are usually the result of the operator proceeding with his duties during imperfect anæsthesia. It is far better for a patient to inhale nitrous oxide on two or more occasions, and to have comparatively little done at each sitting, than for him to experience the discomforts of partial anæsthesia.

Whether the gas should be administered *per se* or with **oxygen** is a matter which will be discussed in the following chapter (p. 68). By administering a small quantity of oxygen with nitrous oxide a longer inhalation, and therefore a longer anæsthesia, is rendered possible. Hence, if an anæsthesia of somewhat longer duration than usual is desired by reason of the nature of the operation, and if the administrator has oxygen at his command, the use of a proper percentage of this gas with the nitrous oxide may be of signal benefit.

Whilst no anæsthetic is at present known which can compare with nitrous oxide, with or without oxygen, for dental operations lasting from twenty to forty-five seconds, differences of opinion exist as to the most suitable anæsthetic and method of administering it, when unconsciousness of about twice this duration is required. An average operator can extract two teeth or roots of average difficulty, in an average patient, who has been placed fully under nitrous oxide, without the patient experiencing any pain or disagreeable sensation. But suppose three or four teeth, more or less firmly rooted, have to be removed at one sitting, what plan should be adopted by the administrator? Three courses are open to him, viz.: (1) to administer nitrous oxide as fully as possible, and, in the event of the anæsthesia being of insufficient duration, to re-apply the face-piece before consciousness returns: (2) to allow the patient to return to consciousness, and then to repeat the inhalation: or (3) to prolong the anæsthesia of nitrous oxide by the addition of a small quantity of ether vapour (Part II. Chap. III.). Bromide of ethyl does not appear to be as satisfactory an anæsthetic as its advocates would have us suppose. It is, of course, impossible to lay down rules which will apply to every case. Should the nature of the operation be such that the patient's head can be arranged and kept vertically in the chair, the first of the three plans may be chosen, because the blood which has escaped during the first half of the operation will, in the vertical position of the head, flow into the floor of the mouth and not to the back of the throat. This re-application of the face-piece during returning consciousness should not be practised with the head thrown back; but, if a further period of anæsthesia be necessary, the patient should be allowed to come round, and, after all hæmorrhage has ceased, more nitrous oxide administered. This re-application of nitrous oxide, if quickly carried through, and if unattended by the swallowing of blood, rarely leads to any after-discomfort of the patient. A double administration, however, with an interval of consciousness, is more frequently followed by retching or vomiting, more especially if food is present in the stomach, because a small quantity of blood or blood-tinged saliva is liable to be swallowed between the two inhalations. The addition of what is known as a 'whiff' of ether after nitrous oxide answers well when the stomach is quite empty, and when care is taken to prevent blood from being swallowed during or immediately after the operation. In my experience disagreeable after-effects, such as nausea and headache, are a trifle more common after a small quantity of ether than after a double administration of nitrous oxide.

It is hardly necessary to point out that, whilst in some cases a dozen or even more teeth may be removed under a single administration of nitrous oxide, a single tooth or root may present such difficulty in extraction that the most profound degree of etherisation for several minutes or longer may be necessary. But as it is almost impossible to say with certainty what length of anæsthesia will be required for an apparently difficult dental operation, I am of opinion that the patient should, in the first instance, be given the chance of having the tooth or teeth removed under nitrous oxide. It is unsatisfactory to have induced a deep ether anæsthesia for a tooth supposed to be liable to present great difficulties in its extraction, and to find that it could easily have been removed under nitrous oxide. Should the operator fail to extract a difficult tooth under nitrous oxide, ether should be administered for a sufficient length of time to ensure a successful operation.

Children.—Children take nitrous oxide well; but as they rapidly recover from its effects, and are more susceptible than adults to muscular twitchings ('jactitation'), the painless extraction of teeth under the influence of this anæsthetic is not always an easy matter. The anæsthesia produced by nitrous oxide in the presence of oxygen is more satisfactory in its nature than that of nitrous oxide alone, as it gives longer time to the operator, and is unattended by jactitation. If anything more than a very short anæsthesia is required, the administrator will do well to place the little patient under ether, preceded by nitrous oxide, as described on p. 180. In employing nitrous oxide for children, it is a good plan to warn the friends of the possibility of the occurrence of screaming, a not infrequent reflex phenomenon in these subjects.

The Position of the Patient.—This is of importance in administering an anæsthetic for a dental operation. Nitrous oxide and ether are specially valuable in these cases, because either or both of them can be safely administered to persons in the sitting posture. The anæsthetist should see that his patient is comfortably seated in the operating-chair. His legs should be so adjusted that, in the event of movement or opisthotonic rigidity occurring, the feet cannot become entangled in the foot-rest, or the heels used for supporting the arched body. The patient's head should be as vertical in the chair as is compatible with the convenience of the operator. When the head is thus placed blood will flow into the front of the mouth; the tongue will not tend to gravitate backwards; stray teeth, roots, or portions of stopping will, if carelessly dropped, remain on or at the side of the tongue; and coughing and retching from the presence of saliva or an enlarged uvula will not be liable to occur. There are, of course, many cases, and especially when the upper jaw has to be operated upon, in which this position of the head cannot be adopted. But even in these the administrator should see that the head is not thrown further back than is really necessary. When, from the condition of the patient, the A. C. E. mixture or chloroform is considered to be preferable to nitrous oxide or ether, the semi-recumbent or recumbent posture should be enforced. Such cases are, however, extremely rare.

Mouth-Props.—Before administering an anæsthetic for a dental operation it is customary to insert some form of mouth-prop, in order to avoid delay in separating the jaws when the patient is under the anæsthetic. The plan is a good one for very short operations (20–60 seconds) under nitrous oxide or nitrous oxide and ether. But when a more prolonged anæsthesia (1–10 minutes or longer) is needed, a prop should not be used. Anæsthetics are not taken nearly so well when the mouth is propped widely open as when it is closed, owing to the tongue being forced towards the pharynx, and so favouring difficult breathing. In a very short administration this difficulty will hardly have time to come into play; but the case is different when proceeding to deep etherisation. Much of the success in the administration will depend upon the efficiency and adjustment of the prop. The mouth-prop used should not be liable to slip: it should be very strong: it should be simple in construction: it should be capable of being quickly and thoroughly cleansed: and, lastly, it should give the operator as much room as possible in the mouth. For several years I have been attempting to devise a gag to fulfil all these requirements; that shown in Fig. 7, p. 85, is in my judgment the best. Corks are liable to slip, as also are most of the ordinary props furnished with soft rubber ends, and supplied by the instrument makers. The former, moreover, may become so compressed during masseteric spasm that, when the face-piece is removed, the mouth is not sufficiently wide, and delay ensues. The slipping of a prop during the administration of nitrous oxide is a *contretemps* which, though trivial in itself, should be guarded against as much as possible. Should it occur, the best plan, as a rule, is to let the patient come out of the anæsthesia and to re-adjust the prop more securely; for if time be taken up in opening, with a Mason's gag, the mouth of a patient deeply under nitrous oxide, there may not be a sufficiently lengthy anæsthesia for the operation to be painlessly performed. When both sides of the mouth have to be operated upon, an attempt should be made to prop the mouth open with a gag which will allow of the operation being performed without the gag being removed. The props of Figs. 8 and 9, p. 85, may be used in such cases. But should there be any chance of such a prop slipping, it is better to employ one of those shown in Fig. 7, and, when the operator has finished with one side of the mouth, to quickly introduce a Mason's gag on that side, at the same moment that the prop is removed to allow of the second half of the operation being performed. Care must be taken, when inserting the Mason's gag, lest teeth be injured, or a mobile jaw dislocated. All mouth-props possessing springs, joints, or other complications should be avoided, not only because of their liability to break or get out of order, but because of the difficulty of keeping them perfectly clean.

Should the patient have **difficulty in opening the mouth** special care must be exercised (see Illust. Case, No. 31, p. 295). As a general rule the anæsthesia of nitrous oxide is not of sufficient duration to allow of forcibly opening the mouth and of extracting the offending tooth. The teeth should be separated as far as the patient can allow by means of a small prop, Fig. 3, p. 82, which will not slip, and gas followed by ether should be given. When the face-piece is removed the mouth may be opened to the desired extent by a Mason's gag. It should be a cardinal rule never to give an anæsthetic to these patients without either inserting a small prop, or, should this be impracticable, without having at hand means for immediately separating the jaws should occasion require. When the teeth can only be separated to a very slight extent, or when the front teeth meet but there is sufficient space further back, it is an excellent plan to insert a Mason's gag *before* applying the face-piece for gas, or gas and ether. Care must be taken to exclude air where the pad of the face-piece crosses the arms of the gag. When a sufficient anæsthesia has thus been induced the mouth may be readily opened without loss of time.

Long Dental Operations.—When numerous difficult teeth or roots have to be removed at one sitting, and an anæsthesia of some minutes' duration is needed, ether (preceded by nitrous oxide as described on p. 183) should be given to its fullest extent. I find it an excellent plan, in these cases, to have at hand two sponges attached to one another by a piece of string. One sponge should be about the size of an average orange, the other should be smaller. Both sponges should be moistened. When the patient has been thoroughly anæsthetised, the mouth should be opened by a Mason's gag, and one of the sponges passed to the back of the throat. The sponge should not be tightly jammed behind the tongue, but rather loosely placed, out of the way of the operator. By this simple procedure blood is prevented from gaining access to the pharynx, and any loose teeth or fragments of teeth which may fall from the forceps will remain in the oral cavity. Breathing is little if at all interfered with when the sponge is properly adjusted. Directly the operation is over the sponge should be pulled out, and the patient bent forwards in the chair for the escape of blood from the mouth.

C. OPERATIONS IN THE REGION OF THE NECK NOT INVOLVING THE AIR-PASSAGES.

In administering anæsthetics for operations in the region of the neck the following points must be borne in mind :—

(1.) Any **embarrassment in respiration** will be quickly followed by considerable venous turgescence, which may render the operation more difficult of performance than it would otherwise have been. It is hence desirable to avoid all coughing, straining, and hampered respiration, by maintaining a deep anæsthesia.

(2.) **Ether** leads to greater vascularity, and more especially to greater venous engorgement than **chloroform**. But when ether is administered with a sufficient supply of air, and when respiration is regular and unembarrassed, these inconveniences are so lessened that they are not of sufficient magnitude to outweigh the undoubted advantages of ether over chloroform for routine use. The vascularity under ether is far greater in the first ten minutes of the operation than later on.

(3.) In some cases the **pneumogastric** nerve may be interfered with, and reflex phenomena of a more or less threatening character may possibly result.[1] I have met with two or three cases bearing upon this point (see Illust. Cases, No. 32, p. 304, No. 38, p. 318, and No. 39, p. 319).

In operations upon the neck the **pupils** are often very mobile, and persistent dilatation is frequently met with, more especially during the removal of deeply seated glands.

It is said that there is a danger from the **entry of air into veins** during these operations; but there is very little evidence in favour of this view (see p. 227).

Recovery from the effects of the anæsthetic may be more tardy than usual after neck operations, owing to the **tight bandaging** which is often necessary. The anæsthetist should not leave his patient till distinct signs of returning consciousness have been manifested.

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[1] Mr. Jacobson ('Operations of Surgery' 1st edition, p. 451) says, with regard to deep-seated operations in the neck, "Throughout these operations which may necessarily be prolonged and attended with loss of blood, and in which important parts may be disturbed and pulled upon, the surgeon should keep himself informed as to the effects of the anæsthetic." And Mr. Edmund Owen (*Practitioner*, Nov. 1891, p. 324) quotes two cases in which it is probable that the dangerous conditions met with were of reflex (vagal) origin.

D. OPERATIONS INVOLVING THE PLEURA OR LUNG.

Patients requiring these operations are, as a rule, suffering at the time from respiratory difficulties more or less pronounced. The reader is therefore referred to the previous chapter (p. 23) for remarks bearing upon the use of anæsthetics in persons thus affected. But although the condition of the patient should primarily occupy our attention, we must also take into account the possibility of circulatory or respiratory difficulties occurring in connection with the operation itself.

The **position of the patient** in these cases is a matter of importance. Should the lateral position be necessary, the affected, or more affected side should, if possible, be lowermost, in order to allow of the free expansion of the healthier lung. Unfortunately many operations upon the pleura or ribs cannot be performed unless the affected side is uppermost, or the patient is lying almost prone. The prone or semi-prone position is an unsatisfactory one under any circumstances,[1] as it is liable to interfere with respiration; but it is more especially hazardous when a considerable proportion of the trunk-weight is allowed to tell upon the only efficient lung. The administrator should, at all events, *induce* anæsthesia whilst the patient is lying in a favourable position; and then observe whether any effects follow the change of posture. In chronic cases, in which the healthier lung has become enlarged and accustomed to increased work, the position of the patient is not of nearly so much importance as in more recent cases.

When a **purulent or gangrenous cavity** of the lung or pleura communicates with the bronchi, coughing must be avoided; otherwise respiration may become embarrassed by pus or gangrenous matter obstructing the air-ways.

During the **withdrawal of fluid** from the pleural cavity the circulation of the patient should be watched, and any signs of failure reported to the operator. Syncope is said to have occurred from the sudden return of the heart towards its proper position. I myself have never witnessed any symptoms of this nature.

Operations upon the lung may be attended by **hæmoptysis** during the administration, and it is hence especially desirable, in such operations, to keep the patient upon his affected side, so that the bronchi of the unaffected lung may remain as free as possible for respiratory purposes.

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[1] See remarks, p. 32.

With regard to the **most appropriate anæsthetic**, it is difficult to lay down definite rules. The condition of the patient must be the chief guide. From the point of view of the surgeon chloroform is preferable to ether;[1] but there are many cases in which this latter anæsthetic should be used in preference to chloroform. Whenever possible ether or an ether mixture should be chosen; for although it may cause some increase in the difficulty of breathing, the circulation will be well maintained (see Illust. Case, No. 8, p. 174).

E. ABDOMINAL OPERATIONS.

The success of many abdominal operations is not a little dependent upon how the patient behaves under the anæsthetic, and upon the after-effects of the agent employed. **Laboured or jerky respiratory movements** greatly interfere with many delicate operations within the abdomen; and **coughing, retching,** or **vomiting** are equally inconvenient to the operator, and should be studiously kept in abeyance. Owing to the fact that under ether respiration is somewhat deeper, quicker, and more liable to temporary interruptions than under chloroform, many surgeons prefer the latter anæsthetic, and some go so far as to consider ether wholly inapplicable in abdominal surgery. But the behaviour of the patient under ether is greatly dependent upon the manner in which the anæsthetic is administered. I have often seen ether given without the patient ever having been really surgically anæsthetised during the operation. Movement, incessant cough, occasional retching, and possibly vomiting have one and all testified to the faulty administration. There are some exceptional cases in which ether is not well borne. But in the large majority of cases none of these difficulties should arise. If the administrator employ the asphyxial element of etherisation in too great a degree, or keep the patient too deeply anæsthetised, the respiration will be laboured and jerky; whilst if he err in the opposite direction he will run a risk of allowing the **abdominal muscles** to become **rigid**, and the patient to cough and strain. He must hit off the happy mean in each case; and with care it will be possible to secure a quiet and satisfactory anæsthesia in nearly all cases. Many operators urge that **vascularity,** hæmorrhage, and **oozing** are greater during the use of ether than when chloroform is being employed. This is doubtless the case, but the difference is not very great. I have frequently known surgeons complain of excessive vascularity whilst chloroform was being used; and, on the other hand, whilst administering ether, I have been told by the operator that, had he not known, he would have concluded from the general appearance of the parts that chloroform was being given. Some surgeons who have discarded chloroform for ether in abdominal surgery believe that, though the vascularity at the time of the operation is somewhat greater than under chloroform, the chance of any secondary hæmorrhage almost disappears when ether has been used. Furthermore, there is good reason to believe that the comparatively slight vascularity often noticed under chloroform is sometimes connected with an undesirable degree of cardiac depression—such a degree as is best avoided. If the pulse at the wrist is full, soft, and regular, as it should be, and the lips and cheeks are of good colour, the surgeon may have trouble from hæmorrhage even under chloroform. If, however, as is often the case with chloroform, the patient's circulation is not very satisfactory, hæmorrhage will be less, and the operation easier of performance. Then again, some operators object to ether in these cases because of the greater frequency of vomiting after its use. Although we must admit that retching is more often met with after ether than after chloroform, such retching usually occurs before the patient has regained consciousness, and does not persist. Chloroform sickness comes on later, and when it does arise is far more frequently persistent than the nausea and vomiting after ether. Although we must admit that, from the operator's point of view, ether is not quite so satisfactory an anæsthetic as chloroform in abdominal surgery, we have yet to decide whether the case is sufficiently strong in favour of the latter agent to justify us in recommending to the unskilled as well as to the skilled an anæsthetic which, so far as the safety of the patient is concerned, is inferior to ether.

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[1] Mr. Pearce Gould, who has had considerable experience in the surgery of the lung and pleura, tells me that he much prefers chloroform to ether for such operations.

In administering an anæsthetic for **acute intestinal obstruction** the anæsthetist incurs no small share of responsibility in the case. This has been already pointed out in the preceding chapter (p. 28). Patients with obstruction of the bowels are not good subjects for general anæsthesia.[1] The administrator should make it a rule to keep the patient's head well upon its side throughout; for vomiting comes on very quietly in these cases, and if the anæsthetist be not on the watch he may suddenly find his patient verging on asphyxiation from ejected fluids having entered the larynx. When there is a tendency to closure of the jaws, and the upper and lower teeth meet accurately, a little mouth-prop (Fig. 3, p. 82) may be kept in position with advantage, in order that the mouth may at once be opened and cleared if necessary. Another point worthy of mention is that patients requiring these operations will often be found to be partly under the influence of morphine or opium. The anæsthetist should ascertain this point; and, should an opiate have been given, very little of the anæsthetic will be needed (see remarks on p. 273). Ether often cannot be employed when the abdomen is very greatly distended and the respiration hurried; the best anæsthetic under such circumstances appears to be the A. C. E. mixture, given upon a Skinner's mask, as described in Illust. Case, No. 18, p. 247. Should ether be preferred, and it may often be advantageously chosen for the more chronic cases, the asphyxial element of the bag inhaler must be used with caution. If the patient be very weak the open method should be employed.

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[1] We are indebted to Mr. Greig Smith for some valuable remarks in this connection. (See *Brit. Med. Journ.*, March 12, 1892, for an abstract of Mr. Greig Smith's paper which was read before the Roy. Med. and Chir. Soc., on March 8, 1892, and was entitled 'Enterostomy in Intestinal Obstruction.') The writer urges that general anæsthesia should never be induced when the

It is usually taught that there is some risk of heart failure during the **evacuation of fluid** from a distended abdomen. I have never seen any symptoms of this nature, although I have watched for them. I should add, however, that as a general rule the patients have at the time either been under ether or a mixture containing ether. In my experience the respiration, and with it the pulse, has always improved during and immediately after the evacuation of fluid (see Illust. Case, No. 17, p. 247).

Operations within and about the pelvic cavity are particularly prone to set up **loud crowing inspiration**. I have met with this condition in many cases of removal of the vermiform appendix, in other intestinal operations, and in ovariotomy. It is far more common in florid and in moderately healthy subjects than in feeble persons (see p. 221). Hiccough, too, may give some trouble during the use of anæsthetics in patients suffering from intestinal obstruction (see p. 282).

With regard to the **depth of anæsthesia** necessary in abdo-

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stomach is full of fluid. The stomach should be artificially evacuated; or a local anæsthetic employed. He further advises that only a light form of anæsthesia should be induced for the incision of the parietes, and that the patient should then be allowed to come round. Many speakers on Mr. Greig Smith's interesting paper agreed that manipulation of the intestine could be conducted, comparatively speaking, without pain.

minal operations, everything will depend upon the condition of the patient. Should the general health be good, as is often the case when ovariotomy or oophorectomy has to be performed, very deep anæsthesia should be maintained throughout, even till the last stitch has been put in; but should the patient be feeble or exhausted, a lighter anæsthesia may with safety be maintained.

There is one more point worth mentioning in connection with abdominal surgery. I refer to **flushing out the abdomen** with hot water. This procedure usually improves the respiration, the pulse, and the colour of the patient, whilst it not uncommonly sets up a reflex crowing condition of the breathing. But after the flushing is over the pulse is apt to flag; and I have known rather disconcerting symptoms to be thus initiated.

F. OPERATIONS UPON THE GENITO-URINARY ORGANS AND RECTUM.

In these operations a **very profound anæsthesia** is, generally speaking, necessary. This is principally owing to the fact that the genito-urinary organs and rectum are richly supplied with nerves whose sensibility is often exaggerated by the presence of a morbid condition. Moreover, patients suffering from these affections are often highly nervous and peculiarly sensitive, or unhinged by continued pain and sleeplessness. Reflex phenomena, such as loud crowing inspiration, 'hesitating' expiration, general muscular rigidity, &c., are therefore more than usually prone to make their appearance. The patient should never be touched by the surgeon till stertor, relaxation, and other signs of a deep narcosis are present.

There is little worthy of special notice concerning operations upon the **external genital organs** beyond what has just been said. In the surgery of the **bladder**, however, the administration of the anæsthetic becomes a matter of no small importance. Straining, attempted vomiting, jerky breathing, and struggling are almost as inconvenient during vesical examinations and operations as in abdominal sections; and it is, therefore, the duty of the anæsthetist to avoid, as far as possible, all such symptoms. Moreover, when the bladder is distended during lithotrity, or supra-pubic lithotomy, there is, as pointed out by Mr. Buckston Browne,[1] a distinct risk of the organ giving way should the patient struggle or violently strain during the operation. Patients suffering from bladder affections are usually elderly, and are not infrequently the subjects of obesity, emphysema, and chronic bronchitis; in other words, they are not always the easiest patients to anæsthetise. Should the operator find it necessary to place a pillow under the loins the resources of the anæsthetist may still further be taxed by reason of the additional difficulty thereby imposed upon the act of respiration. Distension of the bladder in a patient whose breathing is principally diaphragmatic will at once increase the rate and depth of respiration. I know of no greater problem in the administration of anæsthetics than that of keeping the breathing of an emphysematous patient sufficiently tranquil to meet the requirements of the operator, when the bladder and rectum have been artificially distended preparatory to a supra-pubic operation. It is in such cases as these that ether is quite inadmissible, and the A. C. E. mixture or chloroform becomes necessary.

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[1] This point was referred to by Mr. Buckston Browne during the discussion on a paper which he read before the Med. Soc. on April 13, 1891 (*Proc. Med. Soc.*, vol. xiv. 1891, p. 359).

In operations upon the **kidney** there is often considerable tendency to surgical shock, and as a general rule ether is therefore preferable to chloroform. The shock is likely to be greater in feeble than in moderately healthy persons (see Illust. Cases, No. 35, p. 316, and No. 41, p. 321).

A few words may be said concerning the use of anæsthetics in **rectal surgery**. Full-blooded, well-nourished patients and those in average health pass through these operations without giving any anxiety to the anæsthetist, always provided that ether be employed, and the deepest anæsthesia maintained. But there is a certain type of patient, with whom every surgeon who has had much experience in this department must be familiar, who requires careful handling. He is rather pale from occasional loss of blood, of spare build, and from having been greatly overworked and over-taxed in his profession or business, and worried by his rectal disorder, he has become nervous, and altogether unhinged. Such a patient may show signs of feeble circulation during or after the use of the anæsthetic. The symptoms are probably reflex in character (see p. 316).

Unless contra-indicated by the condition of the patient, ether should invariably be used in all cases of this group.

G. OPERATIONS INVOLVING THE BRAIN AND ITS MEMBRANES.

Patients about to be subjected to these operations are sometimes more or less **drowsy or comatose** at the time of administration; and the anæsthetist should therefore carefully ascertain the exact condition of the patient before giving the anæsthetic (see p. 273). So far as the actual performance of the operation is concerned, the best results appear to have been obtained by the use of **chloroform and morphine.** Professor Victor Horsley was the first to introduce this practice into cerebral surgery, and he speaks very highly of the advantages which it possesses in lessening cerebral congestion. But, as will be subsequently shown when discussing the effects of morphine in conjunction with anæsthetics (Part II. Chap. VIII.), this mixed narcosis is by no means free from grave objections, more especially when drowsiness is present. Should a preliminary injection of morphine have been given, the anæsthetist should administer chloroform in small quantities at a time, and attempt to secure an analgesic rather than a true anæsthetic state. Should no morphine have been administered, deep anæsthesia will, at all events at first, be necessary. I have often given the A. C. E. mixture (not preceded by morphine) for these operations with satisfactory results. Ether, too, has been used in a large number of cerebral operations, and with success, so far as the behaviour of the patient under the anæsthetic, and the subsequent recovery have been concerned. But owing to the somewhat greater vascularity of the brain and its meninges during the use of ether, this anæsthetic is by many regarded as inferior to others from the operator's point of view.

H. PARTURITION AND OBSTETRIC OPERATIONS.

Of all the anæsthetics at present known, chloroform is the most suitable for administration during **natural labour.** It quickly produces an **analgesic** state without materially affecting uterine contractions. The patient passes into a dreamy condition, with rather deep respiration, and a pleasant feeling of numbness in the extremities. Speaking generally, chloroform should not be pushed beyond this point. It is not desirable to commence the administration until there is distinct evidence that true labour pains have begun. When the patient shows by her movements that a pain is approaching, chloroform should be applied; as little as possible given; and even before the 'pain' has actually passed off the anæsthetic should be withdrawn. The patient should be allowed to recover completely from the analgesic effects of the drug between the 'pains'; and in these periods food or stimulants may be taken. During the expulsion of the fœtus Spiegelberg[1] recommends that consciousness should be allowed to return in order to lessen the risk of the perinæum becoming ruptured. Most obstetricians agree that if chloroform be given more deeply than is here suggested there is a risk not only of uterine inertia, and a prolongation of the labour ensuing, but of *post-partum* hæmorrhage, more especially in persons predisposed to this condition. **Chloroform should not be employed** when the uterine contractions are feeble, when small doses of the drug appear to retard labour,[1] or when any great respiratory difficulty is present.

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[1] A 'Text-book of Midwifery' (New. Syd. Soc.), vol. i. p. 268.

When **true surgical anæsthesia** is required, as for turning, instrumental delivery, craniotomy, and other operations, ether should, as a general rule, be given. Though the use of chloroform in analgesic doses during labour may be said to be free from risk, there is no reason to suppose that when this anæsthetic is pushed to its fullest degree this almost absolute immunity from danger is to be relied upon.[2] But seeing that chloroform has been very largely used for obstetric operations requiring deep anæsthesia, and that very few fatalities have occurred, it would seem that there must be some explanation of this great freedom from accident. When fatalities under chloroform have occurred in surgical practice at the very outset of the inhalation, *i.e.*, before consciousness has been lost, the elements of fright and apprehension have possibly been at work. These elements are, as a rule, wholly absent when chloroform is given to relieve the pains of labour. The patient is occupied with her suffering, and the prospect of speedy relief from pain gives rise to a feeling of comfort rather than to one of alarm. The view that the physiological hypertrophy of the heart enables this organ to cope with any undue strain which may be imposed upon it is probably quite erroneous. A very large proportion of those who have succumbed under chloroform have had healthy and vigorous hearts. Moreover, the clinical fact is established beyond doubt that, in surgical practice, the best subjects for chloroform are those whose general vital functions are somewhat impaired by illness. In the comparatively few cases in which I have myself administered chloroform to its full extent during or immediately after labour, the patients have certainly taken it remarkably well. There has seemed to be a fuller and better circulation and respiration than in ordinary cases. Dr. Lombe Atthill,[3] who has had forty years' experience with chloroform in obstetric practice, suggests the possibility of the safety being due to the fact that "in these cases the involuntary expulsive efforts seldom entirely cease, and as at the expiration of each of these, comparatively deep inspiration follows, it may tend to prevent asphyxia. . . ." Mr. A. H. Tubby[1] very aptly harmonises Dr. Atthill's clinical facts with recent physiological teaching; and his remarks are very interesting. There can be no doubt that in many cases in which chloroform produces unsatisfactory effects, the difficulty seems to be one arising in the first instance from feeble respiratory movements, and consequently an inadequate pulmonary circulation. The deep respirations of labour would obviate this sluggish pulmonary circulation by emptying the right heart more efficiently.

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[1] For further information I would refer the reader to Dr. Galabin's practical remarks. See 'A Manual of Midwifery,' 2nd edition.

[2] It is a mistake to suppose that chloroform accidents during child-birth are unknown. See a fatal case, *Lancet*, Feb. 2, 1889, p. 249. The administrator had given chloroform 400 times before.

[3] *Brit. Med. Journ.*, Jan. 16, 1892, p. 110.

J. OPHTHALMIC OPERATIONS.

In ophthalmic surgery very deep narcosis is necessary. Imperfectly developed anæsthesia is not only liable to be attended by movement, closure of the lids, and other inconveniences, which themselves would interfere with the performance of the operation, but by coughing, straining, and vomiting, which, in cases of this class, may readily cause expulsion of the vitreous. As a general rule ether is the best anæsthetic, and it should be preceded by nitrous oxide (Part II. Chap. III.), or a small quantity of the A. C. E. mixture (Part II. Chap. VI.). The operation should not be commenced till the patient has exhibited all the signs of profound anæsthesia for some two or three minutes. Should ether be badly borne the A. C. E. mixture may be substituted. When ether is contra-indicated from the patient's condition the A. C. E. mixture may be used from the first, and will be found to answer well, more especially in middle-aged or elderly persons. Nitrous oxide is not a satisfactory anæsthetic for these delicate operations. The quiet breathing and usual freedom from cough which characterise chloroform anæsthesia, have led to the rather wide employment of this agent in ophthalmic surgery; but the frequency with which alarming syncope has arisen, more especially during operations for strabismus, should make us very chary in employing chloroform.[2]

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[1] *Brit. Med. Journ.*, Jan. 30, 1892, p. 110.

[2] Mr. Brudenell Carter, in a very able letter to the *Lancet* (Aug. 7, 1875, p. 227), strongly advocates the use of ether in preference to chloroform in ophthalmic practice, and refers to a surgeon who lost sixteen patients under chloroform administered for operations upon the eye.

K. MANIPULATIONS AND OPERATIONS REQUIRING PARTICULAR STATES OF THE MUSCULAR SYSTEM.

Very complete **muscular flaccidity** is essential for the examination of stiff and painful joints, the reduction of dislocations, and the setting of fractures. It is equally important, too, when the abdomen has to be examined from without, or abdominal section performed, that all rigidity should be absent. There is a general belief that ether is far inferior to chloroform when muscular relaxation is needed. But ether, if properly managed and freely pushed, will almost invariably produce the desired degree of flaccidity. Ether certainly seems specially called for in reducing dislocations of the shoulder, for chloroform has, curiously enough, proved particularly lethal during this operation.[1] Ether not infrequently appears to fail to produce complete relaxation; whereas the true cause of the failure is a deficient supply of air. Should the air-way of the patient be inadequate, muscular rigidity will often manifest itself, but will pass off when the mouth is propped open, or other appropriate measures taken. If the rigidity persist, the administration should be persevered in, and after a while (10–15 minutes) the desired condition will be reached. Time is the only remedy in many cases. Should the muscular rigidity persist even after ten minutes or so of deep etherisation, I have found it best to wholly discontinue the ether for a minute or two, when the muscular system will often quite suddenly relax, probably from the better air supply. Should this plan fail, a few drops (m. x or so) of chloroform sprinkled on lint will usually quickly succeed, and the ether may be subsequently re-applied and continued without further trouble. In very alcoholic subjects I have, on one or two occasions, failed to secure complete abdominal relaxation, not only with ether but with chloroform in large doses.

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[1] Lisfranc, Verneuil, Böekel, and Guillon have all drawn attention to this fact. They believe the fatalities to have arisen in consequence of the "unfavourable position of the patient" during the administration, by which I suppose they mean that respiration is likely to be interfered with during the necessary manipulations. We must remember, too, that complete relaxation is always essential, in other words, that the anæsthetic has to be pushed very freely; that the subjects of dislocated shoulder are often men who have met with the accident whilst under the influence of alcohol; that food is likely to be present in the stomach when anæsthesia is induced; and, lastly, that the administration is not infrequently left in unskilled hands. These facts, together with the suggestion made by the above observers, seem to me to point to the necessity for considerable caution in administering chloroform for the reduction of a dislocated shoulder.

These cases are, however, extremely rare. Nitrous oxide is not a suitable anæsthetic when muscular relaxation is desired.

In most cases of tenotomy, muscular **rigidity** at the moment of section is an advantage, and hence, when the operation is only likely to last a short time, nitrous oxide is particularly appropriate.

L. OTHER OPERATIONS, PROCEDURES, OR CONDITIONS FOR WHICH ANÆSTHETICS MAY BE REQUIRED.

There is nothing worthy of special remark concerning the use of anæsthetics during **other surgical operations and procedures.** A few words may, however, be said with regard to the induction of partial or complete anæsthesia for the relief of certain painful, spasmodic, or convulsive conditions.

General anæsthetics, and more particularly chloroform, are sometimes employed in **renal colic, biliary colic,** and **other acutely painful seizures.** In such cases the selected agent should be administered in analgesic rather than in anæsthetic doses, and, as when exhibiting chloroform in normal labour (p. 54), pain should be relieved without wholly destroying consciousness.

Chloroform has been very extensively used in the treatment of **puerperal eclampsia.** In these cases it is necessary to push the administration somewhat more freely than when the mere relief of pain is desired. Dr. Galabin[1] makes the following practical remarks: "At first the patient may be brought pretty fully under the influence of the drug, but afterwards it may be given only from time to time, and in partial degree. Any premonitory signs of a paroxysm, such as increased muscular restlessness, more rapid breathing, or contraction of the pupils, are indications for giving more of the chloroform, and so, *à fortiori*, is the recurrence of a fit. When chloroform is given judiciously, in this partial degree, the administration may be continued for hours together, without danger." Dr. Playfair[2] points out that chloroform occasionally fails to control the paroxysms. The same author states that the use of an anæsthetic is contra-indicated when the patient is cyanosed. Spiegelberg[3] refers to a case in which sudden death took place during the use of chloroform for puerperal eclampsia.

Chloroform quickly relieves the spasms of **strychnine poisoning.**

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[1] 'A Manual of Midwifery,' 2nd edition, p. 324.

[2] 'Science and Practice of Midwifery,' vol. ii. 6th edition.

[3] 'A Text-Book of Midwifery' (Sydenham Society), p. 220.

In some of the recorded cases it was only necessary to give the drug in analgesic doses;[1] whilst in others deep anæsthesia was produced.[2] In one case[3] chloroform was administered, almost without intermission, for seven hours.

In the treatment of tetanus, chloroform has also been found distinctly advantageous.[4] As in strychnine poisoning, muscular spasm subsides before true anæsthesia is reached; so that it is not necessary to push the chloroform very far. Sometimes a considerable interval of freedom from spasm may elapse after the inhalation, in which case no more of the anæsthetic need be given till the tetanic rigidity recommences. But should the spasms be nearly continuous the administration may be maintained. One case is recorded in which a child was kept more or less under the influence of chloroform for thirteen consecutive days, 100 ozs. being used.

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[1] *Brit. Med. Journ.*, April 22, 1882, p. 575.

[2] *Lancet*, vol. ii. 1875, p. 310.

[3] Ibid., vol. ii. 1867, p. 118.

[4] See 'Braithwaite's Retrospect,' vol. ii. 1877, p. 59: 'On the State of Therapeutics in Tetanus.' See also *Medical Record*, June 15, 1879, p. 243; and *Lancet*, July 31, 1880, p. 171.

CHAPTER IV.

THE SELECTION OF THE ANÆSTHETIC AND THE METHOD OF ITS ADMINISTRATION.

SECTION I.—GENERAL CONSIDERATIONS.

THE anæsthetist of to-day not only has at his disposal a considerable number of reliable agents for the production of general anæsthesia, but also a great variety of methods for their administration. The practice of employing one anæsthetic for all cases must now be regarded as belonging to a bygone time. To ensure success in inducing and maintaining general anæsthesia we must vary our anæsthetic, and our method of using it, according to the exigencies of the cases with which we have to deal. Our first and most important duty is to select that anæsthetic and that method of exhibiting it which is most free from risk to our patient; always provided that there is nothing in the nature of the operation necessitating the employment of some other agent or some other method.

This naturally brings us to the two important questions:—(1.) Which is the **safest** of the various general anæsthetics? and (2.) Bearing in mind the possibility of the safest anæsthetic not being suitable for all cases, which is the **next safest** agent? In considering these questions we shall only take into account nitrous oxide, ether, chloroform, and mechanical mixtures containing the last-named anæsthetic.

(1.) The first question is not difficult to answer. It is universally admitted that nitrous oxide is the safest general anæsthetic at present known. When given by one who has become familiar with its action, there is, practically speaking, no risk whatever in its administration. With regard to the infinitesimal danger which attends its use in less skilled hands, it is highly probable that this is altogether removed by administering the gas with oxygen, *i.e.*, by cutting out the asphyxial factor of the usual mode of administration. If this be so, and the examination of fatal cases would favour such a view, we are justified in giving the preference to the mixture of nitrous oxide and oxygen so far as the actual safety of the patient during artificial anæsthesia is concerned. No fatality from this mixture has been recorded; and from the experience which I have myself had with it, I cannot conceive that any disaster could possibly arise from the direct effects of the two gases, provided, of course, that the oxygen is present in proper proportions. The difference, however, so far as danger to life is concerned, between nitrous oxide on the one hand, and nitrous oxide and oxygen on the other, is so slight that we are warranted in disregarding it; and we may therefore continue to speak of nitrous oxide as the safest anæsthetic known. The use of oxygen is a detail which need not here detain us.

(2.) With regard to the second question considerable difference of opinion has hitherto existed. Nitrous oxide being inconvenient or inapplicable for most surgical operations, it is of great importance that every member of the profession should know which is the safest of those agents which are suitable for prolonged administration. We are fortunately now in a position to unhesitatingly assert that, next to nitrous oxide, ether is certainly the safest of all the general anæsthetics. Statistics, though much abused, make this point perfectly clear. Dr. Julliard, of Geneva, has recently[1] collected, from various reliable sources, records of no less than 839,245 administrations, both of chloroform and ether. The following table shows the relative frequency with which chloroform and ether were used, and the relative death-rate.

Anæsthetic.	Total No. of Administrations.	Total No. of Deaths.	Death-rate.
Chloroform . .	524,507	161	1 in 3258
Ether	314,738	21	1 in 14,987

Dr. Ormsby, of Dublin, has put on record[2] the following administrations:—

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[1] *L'éther est-il préférable au chloroforme?* Par M. le Professeur Julliard, de Genève. (Extrait de la Revue Médicale de la Suisse romande No. 2. février, 1891.)

[2] *Brit. Med. Journ.*, April 14, 1877, p. 446.

Anæsthetic.	Total No. of Administrations.	Total No. of Deaths.	Death-rate.
Chloroform . .	152,260	53	1 in 2873
Ether	92,815	4	1 in 23,204
Chloroform with ether .	11,176	2	1 in 5558
'Bichloride of methylene'	10,000	2	1 in 5000

Mr. Roger Williams draws attention[1] to the value of the St. Bartholomew's Hospital statistics. At this hospital every case in which an anæsthetic is given is entered in a book kept for the purpose. In the ten years 1878 to 1887 inclusive there were 26,949 administrations altogether. The table shows the fatalities and death-rate from the two anæsthetics.

Anæsthetic.	Total No. of Administrations.	Total No. of Deaths.	Death-rate.
Chloroform . .	12,368	10	1 in 1236
Ether	14,581	3	1 in 4860

These statistics are included in Dr. Julliard's, quoted above. The ether death-rate is higher than is usual owing to two patients with intestinal obstruction being included, both of whom were collapsed before operation.

If we combine Dr. Julliard's statistics with those of Dr. Ormsby we obtain the following results:—

Anæsthetic.	Total No. of Administrations.	Total No. of Deaths.	Death-rate.
Chloroform . .	676,767	214	1 in 3162
Ether	407,553	25	1 in 16,302

In other words, statistics seem to show that **ether is more than five times as safe as chloroform.**

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[1] *Lancet*, February 8, 1890.

If further evidence be deemed necessary in favour of ether as a routine anæsthetic for general surgical purposes, we might quote the views of eminent surgeons and others who are qualified to offer an opinion on the subject. I submit that no surgeon or anæsthetist who has exclusively or almost exclusively employed one anæsthetic should be allowed to influence the judgment of others in this matter; for he would naturally enough be biassed in favour of that agent with which constant practice had made him familiar. But there are innumerable surgeons and practitioners, many of whom have specially devoted themselves to administering anæsthetics, whose opinions, seeing that they are based upon the comparative study of the various agents in use, possess the greatest possible weight. We can have no stronger testimony than theirs; and such testimony is almost without exception favourable to ether and unfavourable to chloroform and other agents. From the numerous clinical observers qualified to express an opinion on the relative merits of ether and chloroform I select the following:—

Mr. Jonathan Hutchinson, in a very forcible article on the safety of ether,[1] says: "I speak from a tolerably extensive observation, both of my own facts and those of others, when I say again, what I have often said before, that I think that we ought to have a clear canon in full force on this most important subject. I have not the slightest misgivings in my belief that the restriction of chloroform would save many lives every year. The canon I would venture to suggest is this: *Never give chloroform alone in the first instance; let it be either preceded by ether or in mixture with it.*" (The italics are Mr. Hutchinson's.)

Mr. Pridgin Teale,[2] of Leeds, stated that 'he felt very strongly that ether ought to be the anæsthetic taken up by hospitals and schools, and that the men ought to be turned out from these institutions able to give ether, and then they would have at hand an agent which was perfectly safe.'

The late Mr. Clover, whose experience in this branch of practice was very large, and whose skill as an anæsthetist was of the highest order, gradually discarded chloroform in favour of ether. Shortly before his death, he stated[3] that in over 20,000 cases in which he had given nitrous oxide, ether, and ethidene, there had been one fatality, and this had occurred under the last-named anæsthetic.

Mr. Bailey,[4] and Mr. Woodhouse Braine,[5] who have for a great many years devoted themselves exclusively to the administrations of anæsthetics, and who have used both ether and chloroform in some thousands of cases, have no hesitation whatever in their preference for the former agent.

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[1] 'Archives of Surgery,' Oct. 1889, p. 119.

[2] *Brit. Med. Journ.*, November 21, 1891.

[3] Ibid., May 29, 1880, p. 797.

[4] See Ibid., September 19, 1885.

[5] See Ibid., July 22, 1882, p. 153.

My own experience with the two great anæsthetics, ether and chloroform, has led me to regard the former as the more suitable agent for general surgical work; and I venture to assert that, unless strongly contra-indicated by the condition of the patient or the nature of the operation, ether should invariably be employed.[1] I would go even further than this, and urge that, when any doubt exists as to the suitability of ether, this anæsthetic should be tried, and only abandoned in the event of it being badly borne by the patient. Persons regarded as unsatisfactory subjects for ether may often be successfully etherised if the agent be administered in the proper manner. It is not uncommon to find that a patient takes ether far better than has been anticipated.

The great advantage of ether over all other general anæsthetics at present known is that it produces a remarkably stimulant effect not only upon the circulation, but upon the respiration. The circulation of the etherised patient is not easily or quickly depressed, either by an over-dose of the anæsthetic or by other causes. Those accidental conditions, which may seriously lower cardiac action during chloroformisation, appear to have less influence in a patient under ether. The sitting posture is not liable to be attended by evidences either of circulatory or of respiratory depression. The act of vomiting is rarely if ever accompanied by syncope. Moderate deprivation of air is an advantage rather than a danger. Lastly, patients are not so susceptible to grave reflex circulatory depression as when chloroform is being exhibited.

The respiration under ether is almost invariably so deep and audible that the slightest departure in the direction of failure must at once attract attention. This, in actual practice, is a great point in its favour. The respiration under chloroform, although one of the most reliable of guides as to the depth of anæsthesia, is so often shallow and quiet, even though the patient is doing well, that the anæsthetist is more likely to overlook symptoms of a dangerous character when they first arise. There is another point worth mentioning now that we are comparing the breathing under ether with that under chloroform. Owing to the greater strength of the respiratory movements under the former anæsthetic, there is less objection to placing the patient in certain constrained positions than when chloroform is being administered (see p. 32).

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[1] On the field of battle, where portability becomes a matter of vital importance, and in very hot climates, chloroform is certainly preferable to ether; but with these exceptional circumstances we are not now concerned.

In moderately healthy persons the use of ether is practically free from risk; whereas the majority of those who have unfortunately succumbed under chloroform have been in a robust, or, at all events, a fair state of health at the time.

When dealing with such powerful agents as we are considering, an allowance must always be made for errors in administration. To hit off, as it were, the exact level of anæsthesia which is appropriate in every case is not an easy matter. The advantage of ether here comes out very prominently; for even when this agent is administered in toxic quantities, in the vast majority of instances the administrator has ample time to resuscitate his patient. The workable area with ether is a large one; that with chloroform is small. We may with ether err either on the side of too light, or on the side of too deep an anæsthesia, with but little risk to the patient. But with chloroform any departure from that depth of anæsthesia which is proper in each particular case, whether on one side or the other, is liable to be attended by difficulties. When toxic symptoms arise under ether we find the circulation remaining, comparatively speaking, but little affected. This is not so with chloroform. Whatever may be the precise sequence of events in death from an over-dose of the latter anæsthetic, the clinical fact remains, and will always remain, that the fatal phenomena are, to all intents and purposes, cardiac. Failure to resuscitate the patient is due to the impossibility of restoring cardiac action.

With the above considerations before us, we should certainly regard **nitrous oxide** and **ether** as our **two routine anæsthetics**; the one to be employed for very short operations, and the other for those of longer duration. To illustrate this, let us suppose that we have to anæsthetise two patients. The first is a young man, in average health, who is about to have a whitlow incised: nitrous oxide is here the right anæsthetic to employ. The second patient is a middle-aged woman, of average build, and in a moderately good state of health, who is about to have a tumour of the breast removed: ether should here be selected. The manner in which the administration of nitrous oxide should be conducted in the first case does not now concern us; nor must we pause to discuss the advantages of administering nitrous oxide, or a small quantity of the A. C. E. mixture, immediately before ether in the second case. These are merely details which are of secondary importance as compared to the main fact that nitrous oxide is the proper anæsthetic in the one case, and ether in the other. To administer ether or chloroform for a momentary operation, such as the opening of a whitlow, would be a wrong practice in the first case; and the bulk of clinical evidence warrants us in stating that the continuous administration of any other anæsthetic than ether in the second case would be equally erroneous.

The vast majority of cases may be successfully anæsthetised either by nitrous oxide or by ether. There are, however, some patients to whom neither of these anæsthetics should be given: these have been referred to when discussing "The general condition of the patient" in Chap. II. There are, moreover, certain operations which cannot be performed either under nitrous oxide or under ether; and these have been fully considered when dealing with "The nature of the operation" in Chap. III. In the following section of this chapter these exceptional cases will be again brought together in order that the reader may have a clear idea concerning them.

So far as we have gone, we are, I think, justified in the subjoined conclusions:—

1. *Nitrous oxide is the safest general anæsthetic known, and should therefore be selected in preference to other agents unless its use is contra-indicated by the nature of the operation.*

2. *Next to nitrous oxide ether is the safest general anæsthetic, and should therefore be used whenever nitrous oxide is unsuitable or cannot be obtained, provided that no contra-indications to its use exist.*

SECTION II.—SPECIAL CONSIDERATIONS.

A. CASES SUITABLE FOR NITROUS OXIDE.

Nitrous oxide is especially suitable for very brief operations. As a general rule 30–35 seconds of anæsthesia may be depended upon after a full dose of the gas has been administered (p. 107). It is hence a most valuable agent in **dental surgery**.

When the part to be operated upon is not situated within the mouth or nose, an anæsthesia of one to two minutes' duration, or even longer, may be easily secured (p. 111); but absolute stillness, relaxation, and freedom from reflex movement cannot be relied upon for this length of time.

I speak from experience as to the advantage of nitrous oxide for the following operations or procedures:—

Opening superficial and deep abscesses;
Slitting up sinuses;
Examining or wrenching stiff or painful joints;[1]

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[1] Nitrous oxide is chiefly of use in minor cases. When large joints are affected, or when complete relaxation is needed, some other anæsthetic should be chosen.

Removing a toe-nail or finger-nail;
Snipping away external hæmorrhoids;
Passing a catheter or sound;
Examining a painful rectum or vagina;
Subcutaneous division of tendons or fasciæ;
Removing superficial sequestra;
Applying the actual cautery;
Forcibly dilating the anterior nasal passages;
Scraping patches of lupus.

Nitrous oxide is not a thoroughly satisfactory anæsthetic when any very delicate operation has to be performed, or when a perfectly passive condition of the patient is absolutely essential. For example, in ophthalmic surgery, and in urethral operations such as internal urethrotomy, some other anæsthetic should be chosen. The same remark applies to the removal of tonsils or post-nasal growths.

There is often a good deal of pain immediately after certain brief operations have been performed; and this is especially the case when nitrous oxide has been used. The patient quickly regains consciousness and becomes aware of considerable aching and smarting. I have observed this condition more especially after the wrenching of stiff joints and the avulsion of toe-nails; and it is questionable whether in the case of an extremely sensitive person a small quantity of ether should not be added to nitrous oxide, in order to tide over the after-pain.

There are very few patients to whom nitrous oxide should not be given. I have administered it to children of eighteen months, and it has been administered to patients over ninety years of age. Should the patient be suffering from considerable respiratory difficulty, or be very feeble and exhausted, or possess an irregular and flabby heart, I think that nitrous oxide *per se* should not be given, as the temporary withdrawal of free oxygen cannot be regarded as free from risk. There would not be the same objection to the use of nitrous oxide with oxygen (Part II. Chap. I. p. 114) in such cases.

As is well known, free oxygen is, as a rule, entirely withheld during the administration of nitrous oxide; and the anæsthesia which results is, for all practical purposes, remarkably satisfactory. Of late years, however, it has been shown that, in certain cases at least, a better form of anæsthesia is obtainable by exhibiting nitrous oxide with a small percentage of oxygen. Such a modification is obviously beyond the reach of most administrators; but we must here consider it and compare it with the ordinary methods of administering nitrous oxide, *i.e.*, free from oxygen. The following table shows the differences between the two plans of administration.

NITROUS OXIDE FREE FROM OXYGEN.	NITROUS OXIDE MIXED WITH A PROPER PERCENTAGE OF OXYGEN.
1. Requires a simple apparatus and very little practice to become proficient in its use.	1. Requires a more complicated apparatus and considerable practice to become proficient in its use.
2. Rapidly produces anæsthesia.	2. Rapidly produces anæsthesia, but not quite so rapidly as nitrous oxide alone.
3. Features grow livid or cyanotic.	3. Features preserve their colour, or only show slight change.
4. Respiration becomes irregular and jerky. Snorting and stertor usually present.	4. Respiration usually calm and regular. Stertor and snorting absent. Soft snoring often present.
5. Clonic muscular movements ('jactitation') common.	5. Clonic muscular movements absent.
6. Pulse good, but often quick and feeble at acme of anæsthesia.	6. Pulse always good, even at height of anæsthesia.
7. Pupils usually dilated at acme of anæsthesia.	7. Pupils usually of moderate size at acme of anæsthesia.
8. Considerable venous engorgement and swelling of tongue and parts constituting boundaries of upper air-passages.	8. Far less venous engorgement and swelling.
9. Average period of inhalation necessary to produce deep anæsthesia for the extraction of teeth, about 51 secs.	9. Average period of inhalation necessary to produce deep anæsthesia for extraction of teeth, about 110 secs.
10. Average available period of anæsthesia after removal of face-piece, about 30 secs.	10. Average available period of anæsthesia after removal of face-piece, about 44 secs.
11. Average quantity of gas required to produce anæsthesia, about 6 gallons.	11. Average quantity of gases required to produce anæsthesia, 8–10 gallons.
12. After effects (headache, giddiness, nausea, vomiting, &c.) extremely rare.	12. After effects very rare, but somewhat more common than after nitrous oxide alone.
13. Administration often attended by confused dreams, and sometimes by horrible dreams.	13. Dreams rarely unpleasant, and often very pleasant.

From the above table it will be seen, that by using oxygen with nitrous oxide, the asphyxial phenomena of ordinary nitrous oxide narcosis are prevented. The anæsthetic gas is hence rendered safer for those cases in which the deprivation of oxygen would be open to objection.

The use of oxygen with nitrous oxide appears to be specially called for:—

1. In children (who with nitrous oxide alone are very liable to inconvenient jactitation).
2. In anæmic and debilitated patients, who, like children, quickly exhibit muscular contractions, and, in addition to this, remain but a very short time under the influence of nitrous oxide alone.
3. In any one who has previously exhibited great susceptibility to nitrous oxide *per se* (such patients are difficult subjects to manage in dental practice because of the short period of available anæsthesia).
4. In patients who, under nitrous oxide alone, have experienced highly unpleasant sensations.
5. In patients very advanced in years.
6. In patients with very large tonsils.
7. In patients suffering from heart or lung affections.

B. CASES SUITABLE FOR ETHER.

Ether is the anæsthetic which should be chosen, as a general rule, for all operations which cannot be satisfactorily performed under nitrous oxide. It should be our **routine anæsthetic for general surgical work.** There are few patients who cannot be successfully anæsthetised by its means, and there are few operations for which it cannot be given.

It is unnecessary to enter into detail as to the cases in which ether should be administered. With the exception of those above referred to, for which nitrous oxide should be chosen, and those which will be enumerated below, for which chloroform or a mixture containing chloroform may with advantage be used, ether should be invariably selected as the anæsthetic.

Whenever circumstances permit, it is a good plan to **precede ether by nitrous oxide gas or by a small quantity of the A. C. E. mixture**, in order to spare the patient the initial discomfort of etherisation. Chloroform, though frequently used for this purpose, is not as suitable as the agents mentioned. Nitrous oxide has been very largely employed as a vehicle for ether, and in most cases answers very well indeed. Its advantages in this direction will be more particularly considered in the chapter dealing with its administration in combination with ether (Part II. Chap. III.). It is, however, not always easy to obtain nitrous oxide or the apparatus for its efficient administration. Then again, when portability and simplicity are matters of consideration, the administration of 'gas' before ether is out of the question. And, lastly, we must meet with some patients who are by no means good subjects for gas followed by ether. There can be no doubt that the employment of gas and ether is remarkably free from risk to life. But some practice is necessary in order to successfully give the two anæsthetics together; and difficulties are not infrequent during their combined administration. Taking these facts into consideration, I am inclined to the belief that the administration of a small quantity of the A. C. E. mixture before ether, by the method described in Part II. Chap. VI., is deserving of more widespread notice and trial. I have used nitrous oxide with ether for several years; and whilst admitting that for certain patients we have no better means of producing anæsthesia, I am convinced that in other subjects this succession of anæsthetics is not so satisfactory as that referred to. I have found the use of nitrous oxide before ether to be advantageous in most patients between the ages of 6 and 45 or 50 years, provided that they are in moderately good health. The succession is specially indicated in highly nervous and hysterical subjects, owing to the rapid loss of consciousness produced by the nitrous oxide. I have found the use of the A. C. E. mixture before ether of special service: (1) in children of from 1–5 years; (2) in very stout and flabby patients; (3) in most patients above the age of 45; and (4) in those who dislike any closely fitting mask being applied to the face. Patients in whom the deprivation of air is likely to be attended by difficulties, such for example as the very stout, the asthmatic, the bronchitic, the asthenic, &c., are not nearly such good subjects for nitrous oxide before ether as for the A. C. E. mixture before ether. Middle-aged men and women who have become addicted to alcohol and are florid and flabby in appearance will be found to do particularly well with the A. C. E. mixture followed by ether. One great advantage of this mixture over nitrous oxide as a preliminary to ether is that all cyanosis and impeded breathing are prevented—a point of considerable importance when inducing anæsthesia in patients advanced in years, and in those who are the subjects of intra-thoracic or abdominal disease. I have notes of a large number of cases in which I have used this succession of anæsthetics, and have rarely if ever met with any trouble. I have frequently been surprised, when anæsthetising certain types of subjects, at the total absence of difficulties during the administration—difficulties which would certainly have appeared with any other method of inducing deep ether anæsthesia.

C. CASES SUITABLE FOR CHLOROFORM OR MIXTURES CONTAINING CHLOROFORM.

The superiority of chloroform over all other known anæsthetics for allaying the pains of **natural labour** has already been referred to (p. 54).

When the **actual cautery has to be used in or about the mouth or nose**, and when the anæsthesia of nitrous oxide would be of insufficient duration, unmixed chloroform must be employed. Ether is inadmissible by reason of the inflammable character of its vapour. Should the condition of the patient be such that the use of chloroform from the commencement seems unadvisable, the patient may be first placed under ether, and chloroform subsequently administered. After a few minutes of chloroform inhalation the cautery may, with safety, be used.

There are many operations within and about the nose and mouth for which chloroform is more or less essential. When a clear and uninterrupted anæsthesia of more than ten minutes[1] is needed, chloroform is the most appropriate anæsthetic. For most operations, therefore, upon the **palate, tongue, jaws, mouth, nasal cavities, naso-pharynx, and pharynx**,this anæsthetic should be chosen. When circumstances permit, the patient should be first placed well under ether, and the administration of chloroform commenced when the patient shows signs of passing out of the etherised state, but not before (p. 35). Chloroform should only be given throughout when the condition of the patient is such that ether is inadmissible.

In **extreme emphysema**, in **chronic bronchitis attended by expectoration and dyspnœa**, and in **advanced pulmonary phthisis**, chloroform or some mixture containing chloroform should be employed. It is true that ether may often be used in these cases; and when there is any doubt as to its suitability there is no harm in attempting the administration. I have met with several instances, however, in which a satisfactory form of anæsthesia under ether seemed to be wholly unattainable. Many cases of this class may be anæsthetised successfully with the A. C. E. mixture. No definite rules, which will apply to every case, can be laid down. If ether itself seems out of the question, the A. C. E. mixture may be tried, and should it not be satisfactorily borne, chloroform should be substituted.

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[1] By freely administering ether for ten to fifteen minutes before the operation commences a resulting anæsthesia of from five to ten minutes may be secured, during which a great many operations, such as the removal of tonsils or post-nasal growths, opening up the antrum, removing sequestra, excision of a portion of the tongue, &c., may be performed without a re-application of the inhaler.

When **dyspnœa, from narrowing of the upper air-passages,** is present, and anæsthesia is needed, chloroform, or a mixture containing chloroform, must be used and ether avoided. As already pointed out, the use of any anæsthetic in these cases is attended by considerable risk (see p. 23).

In **many cases of morbus cordis with symptoms,** chloroform mixed with ether, as in the A. C. E. mixture, is very well borne (see p. 248). When, for example, a patient has mitral or aortic disease, with some evidence of pulmonary engorgement, an intermittent heart, and a degree of varying cardiac dyspnœa, the A. C. E. mixture has, in my experience, answered better than either ether or chloroform (see Illust. Cases. Nos. 19, 20, and 21, p. 248). In congenital morbus cordis with cyanosis, nitrous oxide with oxygen should be chosen for brief operations, and the A. C. E. mixture for those of longer duration. Not long ago a case was reported to me in which a child with congenital heart disease nearly died under nitrous oxide administered in the usual manner.

Although **very old persons** take chloroform particularly well, I believe a suitable mixture of this anæsthetic with ether, or with alcohol and ether (as in the A. C. E. mixture) is even preferable to chloroform. Old persons whose chests have become rigid seem to be unable to respond efficiently to the demands made upon them by the administration of ether. Up to 65 or 70 years of age patients, as a general rule, may be successfully anæsthetised by ether; but after this age the A. C. E. mixture is better borne. As already indicated, however (Chap. II.), the anæsthetist must be guided not so much by the actual as by the apparent age of his patient. There are very well preserved patients of 70 who take ether without any inconvenience; while, on the other hand, we not infrequently meet with men and women who, though but 50 or 55 years of age, have all the appearance of, and behave under anæsthetics in the same way as, patients twenty years older. Whenever, in elderly persons, ether is not well borne, the A. C. E. mixture may be substituted with advantage.

In **extreme obesity** I have found the A. C. E. mixture singularly appropriate, the behaviour of patients under its influence being, as a rule, very satisfactory. I believe the best plan in these cases is to commence with the A. C. E. mixture, and then to see how ether is borne. In this way the anæsthetist will tide over the period of excitement, tonic spasm, &c., under the stimulus of ether—a point of some importance when a dilated and fatty heart, so common in these subjects, is present. If the ether be not well borne the anæsthetist should go back to the A. C. E. mixture. The vast majority of cases will do well with this mixture administered from a Rendle's mask. Exceptional cases will be met with, however, in which even the ether of the A. C. E. mixture produces irritation and irregular breathing, and should such symptoms be inconvenient to the operator, chloroform may be used. I have notes of more than one case in which the operation of lithotrity in a very stout man could not be successfully performed, either with the patient under ether or under the A. C. E. mixture, and chloroform was necessary in order to secure sufficient tranquillity of breathing and freedom from reflex movement in the legs.

In very **marked atheroma** chloroform, or a suitable mixture containing it, is said to be preferable to ether, owing to the risk of cerebral hæmorrhage under the latter agent. But, seeing that ether is constantly being given to very atheromatous subjects, the risk must be very slight indeed—barely worth taking into account.

In **abdominal surgery** chloroform certainly possesses advantages over ether. The relative merits of these anæsthetics have been fully discussed on p. 49.

Some surgeons greatly prefer chloroform to ether for all **operations in the region of the neck.** The disadvantages of ether in these cases have been already considered (p. 47).

The use of chloroform in **cerebral surgery** is referred to on pp. 54 and 272.

Lastly, chloroform is indicated whenever ether, or an anæsthetic mixture containing ether, is badly borne, that is to say, whenever uncontrollable coughing, embarrassed respiration, cyanosis, prolonged tonic spasm, or other signs of intolerance are produced.

CHAPTER V.

THE PREPARATIONS FOR THE ADMINISTRATION.

In order to ensure, as far as possible, a successful anæsthesia, certain preparations for the administration should invariably be made. This remark not only applies to cases in which a protracted administration will be necessary, but to those in which a very brief anæsthesia, such as that afforded by nitrous oxide, is required.

It is always advisable to have a third person in the room during the administration of an anæsthetic.

A. HOUR OF ADMINISTRATION: REGULATION OF DIET.

It is generally agreed that the **early morning** (8 a.m.–9 a.m.) is the best time for the administration of a general anæsthetic for a surgical operation. Putting exceptional cases aside, patients are brighter and fresher in the morning than in the after-part of the day. Those who fortunately possess a placid equable temperament will almost certainly pass a fair night before an operation; whilst nervous and apprehensive persons will have the best chance of obtaining a little refreshing sleep when an early hour is fixed. But the most important reason for choosing the time indicated is that in most cases the stomach is then empty. Adult patients in good health may be allowed their usual meals the day before the operation, provided nothing be taken after 7 or 8 P.M., and that no excess either in food or drink be indulged in. A light and nutritious meal at or about 7 o'clock on the previous evening is generally to be recommended in these cases. I have known patients who have had an exceptionally good dinner the night before the operation, and children who have eaten heartily of pudding before going to bed to eject a considerable quantity of semi-digested food after the anæsthetic on the following morning, even though nothing whatever had been taken during the night. The practice of giving a cup of tea or coffee, a glass of milk, an egg beaten up in milk, an egg with brandy, or in fact anything whatever, at 6 A.M. or 7 A.M. (*i.e.*, two hours or so before an early operation), is open to serious objections. Digestion is often not performed so quickly as is anticipated. The process is said to be very liable to be interfered with by apprehension on the part of the patient; and this may be so in some instances. I have often administered anæsthetics to patients who, four hours before the operation, have had, for example, a little beef tea; and have known such patients to eject considerable quantities of this fluid undigested, immediately after the withdrawal of the anæsthetic. Similarly, I have often known children, who have been kept in ignorance of anything unusual being about to take place, to eject undigested milk several hours after it has been given to them. In fact, there is good reason to believe that patients who are in a fair state of health should be kept even longer without food than is now usually considered advisable. This more particularly applies to cases in which the operation is performed at some other hour than 8 A.M. or 9 A.M. In the case of early operations upon patients in a fair state of health, there is no necessity for anything whatever during the night or small hours of the morning. When it is decided to perform the operation at some other time the case is different.

The next best time to 8 or 9 A.M. is probably **1.30 or 2 p.m.**, *i.e.*, about the patient's usual luncheon or dinner hour. Under these circumstances a light but nutritious breakfast at 8 may be taken, and nothing whatever after.

Should the operation be fixed to take place at some other time than that above indicated, and should the question arise as to the diet of the patient, special care should be taken to keep the stomach as empty as possible; for when the operation is arranged for **11 or 12 o'clock in the morning**, or for **3, 4, or 5 in the afternoon**, persons are liable, unless specially warned, to have had their breakfasts or mid-day meals as usual. It is better to err, if at all, on the side of abstinence. Young adults in good health should, for example, be allowed to remain without food for from five to six hours. This can be done by arranging a good breakfast at 8.30 or so and the operation for 3 P.M. To give beef tea, or milk, or eggs, &c., at 12 would be wrong in these patients. Should the operation be arranged for 11 or 12 in the morning—an hour open to objections—the best plan perhaps is for the patient to have a cup of coffee or cocoa with milk and dry toast at about 6–7 A.M.; but as he will almost certainly be unaccustomed to this light and early breakfast, he may possibly fail to digest it.

The above rules can hardly be adhered to when we have to deal with **exhausted patients**, or with those who are liable to feel faint after a comparatively short abstinence from food or stimulants. Moreover, patients advanced in years should not be kept quite so long without food as younger persons; partly because they more readily show signs of exhaustion, and partly because they are less liable than their juniors to after-nausea and vomiting. Generally speaking, exhausted and asthenic subjects who are to be operated upon in the early morning should be allowed some clear soup during the night; and in extreme cases a little wine, brandy, or whisky may at the same time be taken with advantage. Similar arrangements are indicated when the operation is fixed to take place during the day, *i.e.*, some soup should be given about three hours before the administration. Milk, eggs, and ordinary beef tea are not so suitable as clear soup.

Should the patient's circulation be extremely feeble, it will be a good plan to give an enema of brandy and water, or brandy and beef tea, a short time (twenty minutes or so) before the administration of the anæsthetic. Many have advocated[1] giving a small quantity of brandy or whisky, with about an equal quantity of water, by the mouth; but this practice is not without its objections. I have on more than one occasion known vomiting to be thus induced. If alcohol is to be given at all, it is probably best to give it in the form of enema. If, however, this plan is not thought desirable, the patient may be allowed a tablespoonful of brandy with an equal quantity of water by the mouth, half-an-hour before the operation.

It is generally taught that the regulation of the diet of the patient is not so much a matter of importance in the case of nitrous oxide as in that of other anæsthetics. It is certain that, even though undigested food is present in the stomach at the time of administration, patients are rarely attacked by retching or vomiting either during or after the inhalation of this agent. This is presuming that little if any blood is swallowed by the patient. But should the stomach contain food, and should a small quantity of blood be swallowed, vomiting will be liable to arise. A double administration of the gas is often followed by an unpleasant attack of retching, owing, no doubt, to some blood or blood-tinged saliva gaining access to the stomach during the second inhalation. I have often given nitrous oxide soon after a meal; but it is probably better to allow a couple of hours to have elapsed. The best time for the administration of nitrous oxide is from three to four hours after food. From 11.30 to 12.30 in the forenoon, or from 4 to 5 in the afternoon, are favourite hours for the extraction of teeth under nitrous oxide. Care must be taken with weakly persons not to err on the side of too long a fast, otherwise faintness may be felt. I have known the same patient to take gas far better four hours after food than six hours. It is possible that the sitting posture which is necessary in dental operations rather tends to favour this feeling of faintness. When nitrous oxide with a small quantity of ether is to be given, the patient should be kept as long without food as is desirable in more protracted administrations.

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[1] See Clover, *Brit. Med. Journ.*, Feb. 14, 1874. See also an interesting letter 'On the Value of Alcohol before Chloroform' (*Brit. Med. Journ.*, July 20, 1889).

B. STATE OF THE BOWELS AND BLADDER.

In ordinary surgical practice, *i.e.*, in cases requiring anything more than a transient anæsthesia, it is customary for the bowels and bladder to have been evacuated before an anæsthetic is administered. Arrangements as to the use of purgatives, &c., naturally rest with the surgeon, or usual medical attendant of the case; but I may perhaps be excused for making a few remarks on the subject.

I have not unfrequently known the use of a purgative before the operation to be followed by such depression that the patient has not taken the anæsthetic as well as would otherwise have been the case.[1] In weakly and anæmic subjects, in those who will probably lose a considerable quantity of blood during the operation, and in those who will have to be kept anæsthetised for a long period, care must be taken not to reduce the strength by free purgation. These remarks forcibly apply to patients who have been losing blood from hæmorrhoids. It is especially important in these cases that the rectum should be empty; and very often these are exactly the patients who cannot stand being vigorously purged. The behaviour of such individuals with regard to purgatives should be taken into account. Speaking generally, a mild laxative (suitable to the particular patient) should be given the day before, and an enema on the morning of the operation. The former may be dispensed with, if thought advisable. There is no necessity for the above precautions when a brief anæsthesia has to be induced. An exception should, however, be made to this statement, viz., that in the case of patients about to inhale nitrous oxide the bladder should be emptied, as micturition otherwise might occur during the muscular phenomena produced by this gas. This precaution is specially desirable with children.

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[1] Snow believed that free purgation the night before a rectal operation would be likely to induce syncope during anæsthesia; and he met with cases which appeared to render this view extremely probable. See Snow, *op. cit.*, p. 104.

C. INSPECTION AND EXAMINATION OF THE PATIENT.

Bearing in mind the fact that the phenomena of surgical anæsthesia are largely dependent upon age, temperament, physique, habits of life, quantity and quality of blood, state of the respiration, state of the circulation, and other factors (Chap. II.), we cannot fail to recognise the advantages of ascertaining, as far as circumstances will permit, the general condition of the patient entrusted to our care. In the majority of cases a brief inspection is all that is needed. The more practice the anæsthetist has had, the less need will there be for any systematic examination. It is better, however, to err on the side of an unnecessarily cautious investigation, than to overlook symptoms which, if recognised, would be of service in conducting the administration. When any doubt exists, therefore, as to the state of the patient's health, it is a good plan to employ the stethoscope, or to adopt any other means that may suggest themselves for ascertaining the presence of any important morbid condition. It is a mistake to suppose that a prejudicial state of alarm is brought about by the few simple procedures and questions which are advisable on these occasions. A patient who is in a good state of health is usually fully aware of the fact, and is not likely to feel distressed whilst his heart is being auscultated, and his chest expansion tested. Apprehension is more often caused by the manner in which these inquiries are conducted than by the inquiries themselves. Nervous persons are just as likely to gain comfort and confidence by their state of health being properly gauged, as to suffer from increased dread and alarm. But, even admitting that an examination of the patient is open to objection on the grounds indicated, we are surely not justified in allowing any such objections to carry weight. Every one who has largely administered anæsthetics must be able to call to mind cases which would certainly have gone more smoothly had some particular pre-existing peculiarity or morbid state been recognised before the administration. Aortic disease, mitral stenosis, an extremely slow cardiac action, or emphysema may, for example, be easily overlooked unless care be taken. It is certainly erroneous to argue that as the patient *must* have an anæsthetic there is no need to ascertain his fitness for it. By carefully taking into consideration the condition of the patient, we not only place ourselves in a better position to decide what anæsthetic or anæsthetic mixture should be chosen, but we are often able to anticipate the occurrence of important symptoms during the administration. When circumstances permit, therefore, it is a good plan for the administrator to make himself acquainted with the patient's general state. As already mentioned, this may usually be done without employing the stethoscope; but, whenever there is the slightest indication, the anæsthetist, who is responsible for the safety of his patient, should allow nothing to stand in the way of his making a more thorough examination.

It will be convenient in the present place merely to indicate the more important points to which the attention of the administrator should be directed when his patient is presented to him. A great deal of valuable information, both positive and negative, is afforded by the **general appearance and bearing of the patient.** Let us in a few words consider what may be learnt by simply observing the individual before us. Should he walk to the operating table, couch, or chair, his mode of progression may afford us information. We shall notice whether he moves actively, or whether with considerable hesitation or difficulty. Should the exertion be followed by breathlessness we ought specially to bear the fact in mind. Should the patient be partially or wholly recumbent when we are called upon to anæsthetise him, we should note what position is assumed from choice. We should more particularly pay attention to the number of pillows the patient requires. Those who suffer from chronic bronchitis, emphysema, other affections of the air-passages, or extreme abdominal distension, almost invariably insist upon being propped up to a greater or less degree. Marked orthopnœa will attract attention, and should be regarded as a very unfavourable symptom. Patients suffering from unilateral pulmonary or pleural affections will probably be found lying upon the diseased side. Whilst observing and drawing our inferences from the walk or posture of the patient, we are able, as a rule, to roughly estimate his age. It must be remembered that the anæsthetist is concerned as much with the apparent as with the real age of his patient. The temperament, too, which plays an important part in determining the manner in which an anæsthetic is taken, usually quickly shows itself on these occasions. This is more particularly the case with hysteria. It must be remembered, however, that women who are liable to outbursts of hysteria sometimes conceal their want of control so efficiently that the observer is deceived. The over-worked and the highly-strung patient will be recognised, and should be treated with the utmost gentleness and care.

Previous excesses in alcohol, as a rule, present little or no difficulty in their detection. The general physique of the patient will be observed. Gross, flabby individuals, with a large abdomen, muddy complexion, and double chin will probably not be easy subjects to manage. Florid, muscular young men, who live an outdoor life and enjoy excellent health, are also liable to give the administrator some difficulty. Persons afflicted with extreme obesity may also be regarded as bad subjects for certain anæsthetics. Conversely, patients of slim build, and more or less anæmic in appearance, do particularly well during general anæsthesia. The colour of the patient's face and lips should be noted. A florid rosy tint denotes, as a rule, a good state of health and the absence of nervousness or respiratory derangement. The hectic flush, however, must not be allowed to deceive. Florid, and more especially dusky-looking and congested patients, will be very liable to show cyanosis under nitrous oxide or ether—in fact under any anæsthetic, if air be withheld even to a slight degree. The pallor of true anæmia is readily recognised. Apart, however, from this pallor, we must remember that very nervous and apprehensive subjects are prone to be much paler than usual at the time of administration; their pallor disappears when anæsthesia is established; and, often to the surprise of the anæsthetist, to whom the patient may be a stranger, a good florid colour will persist throughout the administration. The anæsthetist should take special note of the **manner in which respiration is performed**, and if any marked abnormality in this direction be detected a further examination of the patient should be made. If there is no obvious shortness of breath or distress in breathing, and if the respiratory movements are quiet and the colour of the lips good, there is, as a rule, no need for any further examination. It is usually a good plan, however, to ask the patient to take a deep breath. In this way the administrator will see whether the chest expands freely, and whether the respiration is principally thoracic or abdominal. By getting the patient to take a deep breath the administrator may hear if there is any sound suggestive of narrowing of the air-way, bronchial catarrh, emphysema, &c. A loose, frequent, or hollow cough should not escape attention. The cough of simple nervousness is easily distinguishable. The **pulse** should invariably be felt; and as a general rule it is a good plan to **apply the ear or stethoscope to the chest**. Any duskiness, pallor, or breathlessness should suggest a stethoscopic examination. Feebleness, irregularity, intermittency, or marked slowness of pulse should lead to further inquiry.

The **oral cavity should be inspected** by the anæsthetist.

Artificial teeth, even though firmly fixed and apparently safe, should always be removed. It is important that, at the time of administration, there should be nothing within the mouth which is loose or likely to become loose. On one occasion during the administration of ether I discovered a tooth lying loose in the mouth. My attention was directed to it by finding a little blood issuing from the lips. During the closure of the jaws a shaky tooth had apparently become dislodged. It is hence best to see that no such teeth are present, or if present to take special care lest they become detached. I once also found, loose in the mouth, a portion of tartar about the size of a large pea, which must have been left attached to the gum when the patient removed two artificial teeth before the administration. It is said that a 'quid' of tobacco has led to serious results by not having been removed by the patient before taking an anæsthetic. In the case of children, sweetmeats may possibly be present in the mouth at the time of administration. Should the patient be the subject of partial or complete **nasal obstruction**, the anæsthetist must take note of the fact, as the condition is liable to give rise to some difficulty during the administration, unless a little mouth-prop (Fig. 3, p. 82) be inserted between the teeth with the object of maintaining an oral air-way.

D. APPLIANCES AND REMEDIES WHICH SHOULD BE AT HAND DURING THE ADMINISTRATION.

1. Appliances.—Before administering a general anæsthetic it is important that certain appliances should be in readiness in case of need. Whatever anæsthetic may be employed, and whatever the nature and duration of the operation may be, the administrator should have by him :

1. Instruments for opening the mouth and maintaining it in this position.
2. A pair of tongue-forceps.
3. A small basin, a towel, and a small piece of sponge.
4. Instruments for performing tracheotomy.

The anæsthetist should always be prepared to open the mouth of the patient without delay. There are some forms of respiratory embarrassment which can only thus be relieved. When the teeth are more or less deficient, all that is necessary is to introduce a **Mason's gag**. The gag shown in Fig. 1 is, in my experience, the best form. The spring should be strong, so that the blades come closely together, and the notches for the movable catch should be rather, but not too deeply cut. The parts of the gag which come in contact with the teeth or gums should be covered with thin rubber tubing.[1] Should there be any difficulty in introducing this gag, which is not infrequently the case in muscular patients with good teeth, the best and simplest appliance for separating the clenched teeth is a **thin wedge of hard wood** of the shape shown in Fig. 2. A small strong **mouth-prop,** so made that it cannot slip when placed between the front teeth, (Fig. 3) is often of use either for inserting before commencing the administration, or for introducing subsequently should it be found advisable to keep the teeth apart (p. 22). With a Mason's gag, a wooden wedge, and a little mouth-prop, all difficulties dependent upon closure of the jaws may be obviated or removed.

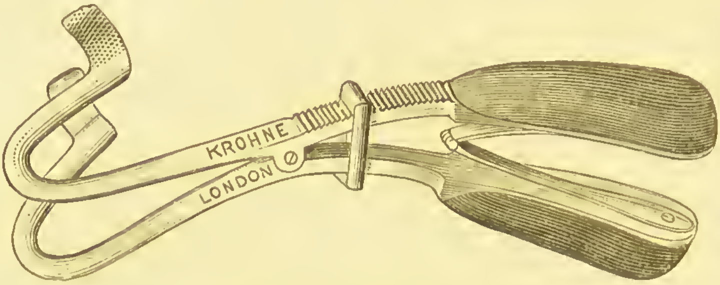

FIG. 1.—Mason's Gag.

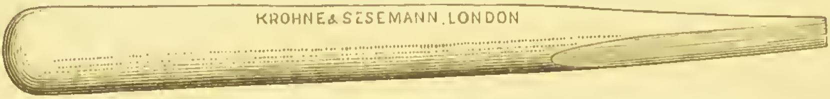

FIG. 2.—Wooden Wedge for separating clenched teeth.

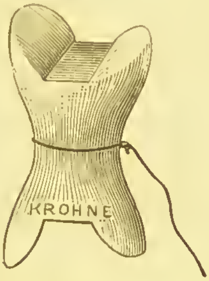

FIG. 3.—Mouth-prop for keeping the teeth apart during the administration (actual size).

With regard to **tongue-forceps**, I believe that those shown in Fig. 4 are as efficient as any. The forceps represented in Fig. 5 (Mr. Woodhouse Braine's) are preferred by some; but they do not grip the tongue quite so well as the ordinary forceps, more especially when the organ is large, firm, and slippery. Moreover, should it be desired to keep the tongue well drawn out of the mouth for a prolonged period, the ordinary tongue-forceps, which seldom if ever fails to bite, will, without the assistance of a bystander, retain its hold upon the tongue. The forceps of Fig. 5 has the advantage that, when the blades are closed, an efficient wedge-shaped mouth opener is formed. I much prefer the wooden wedge of Fig. 2, however, for separating the teeth. Some administrators, following the recommendations of Sir Joseph Lister, use a simple pair of artery forceps, which certainly have the merit of not being liable to slip when once they have taken hold of the tongue.

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[1] The gag shown in Fig. 50, p. 199, which is furnished with tubes for the transmission of chloroform vapour to the back of the throat, will answer as well as the above if not too clumsily made.

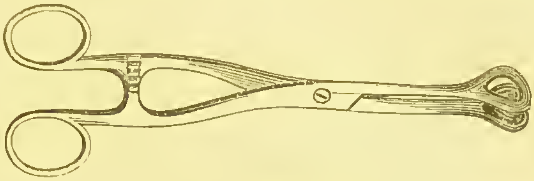

Fig. 4.—Tongue-forceps.

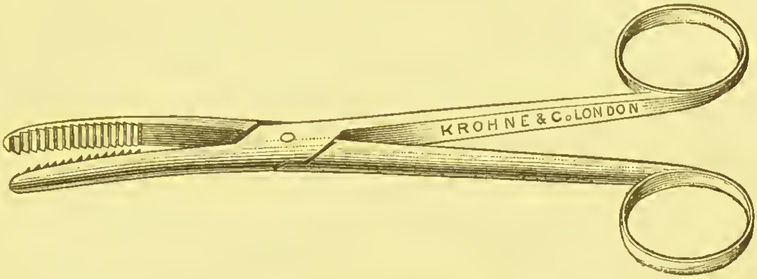

Fig. 5.—Braine's Tongue-forceps.

It is a good plan to fix a moist **piece of sponge** of appropriate size between the blades of the tongue-forceps, so that the mouth may be sponged out if necessary. Should the forceps be required for tongue traction the sponge can readily be removed. The administrator should make it a rule to keep this sponge in readiness in all mouth and nose cases, even though the surgeon has apparently made ample provision for sponging away blood.

A **small basin** should be at hand in case of vomiting, the non-occurrence of which cannot be prophesied with certainty in any instance.

In ordinary surgical practice a **towel** will be found useful for wiping out the corners of the mouth, for rubbing the lips and cheeks (p. 230), or for placing beneath the cheek of the patient as it lies upon the pillow.

Instruments for the performance of tracheotomy should always be at hand.[1] The accompanying drawing shows a convenient **emergency case** which contains not only the appliances which have already been referred to (Mason's gag, tongue-forceps, wooden mouth opener, and mouth-prop), but instruments for the performance of tracheotomy, viz., two tubes, a scalpel, a sharp hook, and a pair of dressing-forceps which answer as dilators.[2]

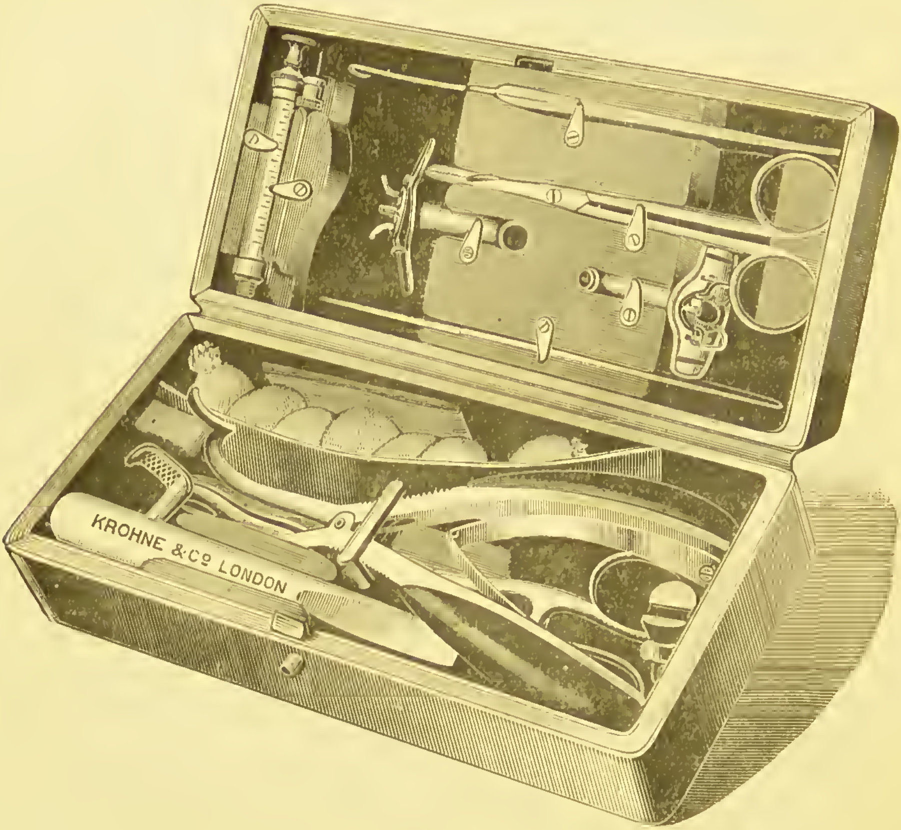

FIG. 6.—Emergency Case, containing Mason's Gag, Tongue-forceps, Wooden Wedge, Mouth-prop, Instruments for performing Tracheotomy, Hypodermic Syringe, and partition for remedies such as Nitrite of Amyl, Digitalis, Strychnine, &c.

In **dental practice** the anæsthetist should have with him **several mouth-props** for keeping the teeth apart during the administration of nitrous oxide or nitrous oxide and ether. Having tried numerous kinds I find the prop shown in Fig. 7, which is made for me by Messrs. Ash & Sons, to answer better than any. It is made of steel, and is so shaped that it adjusts itself to the angle made by the lower jaw receding from the upper. It is furnished with detachable rubber pads, which can be renewed from time to time. When in position it engages several teeth, so that there is no chance of a faulty loose tooth being injured. Five sizes are necessary. All props containing springs or screws are liable either to break, to get out of order, or to be contaminated with blood and other unpleasant matters. A long thin mouth-prop with shallow grooves at each end (Fig. 8) is sometimes useful for fixing between the front teeth, but the administrator must be careful that the teeth between which it is fixed are strong enough to bear the strain. In children, and for certain cases to which detailed reference need hardly be made, a little vulcanite prop with rubber or guttapercha ends, of the shape shown in the adjacent figure (Fig. 9) is often of use. It takes up very little room in the mouth, and can be placed between the last molar teeth, thus enabling the operator to extract teeth which might otherwise be covered.

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[1] A case occurred in my own practice a few years ago which showed the necessity of being prepared with tracheotomy instruments on *all occasions.* Had I not had a tracheotomy tube with me, it is highly probable that I should not have been able to rescue the patient from imminent death. The case is fully described on p. 295.

[2] This little case is manufactured by Messrs. Krohne & Sesemann, and is specially adapted for use in operating theatres and elsewhere when anæsthetics are being employed.

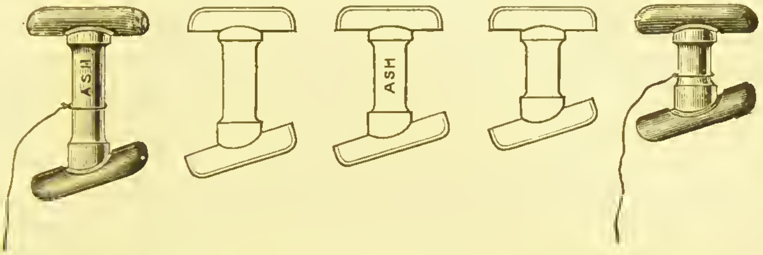

Fig. 7.—Set of five Mouth-props for use in dental practice (half size).

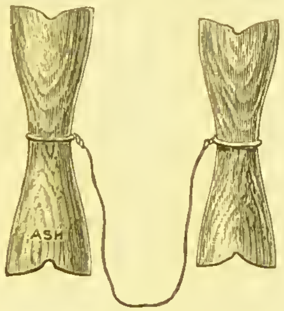

Fig. 8.—Long Wooden Mouth-prop (two-thirds actual size).

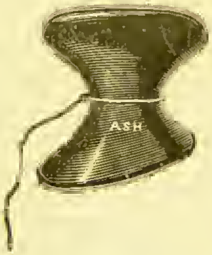

Fig. 9.—Mouth-prop for certain cases (actual size).

When upper back teeth, or bicuspids are to be extracted, Carter's

oral net spoon (Fig. 10) is of value for the reception of fragments that may drop from the forceps or gums during the operation, or for preventing the 'shooting' backwards of bicuspid teeth. The administrator may, however, by simply passing the finger behind the forceps, prevent fragments from falling. The net spoon has the great drawback that it occupies the hands of the anæsthetist which are best employed in steadying the head or supporting the lower jaw. The operator should, in fact, be wholly responsible for the removal of the teeth, stumps, or fragments from the mouth; so that the attention of the administrator need not in any way wander from the patient's general condition. The anæsthetist has not only to see that respiration and circulation are efficiently maintained, but also to watch for evidences of returning consciousness, in order that his patient may feel no pain.

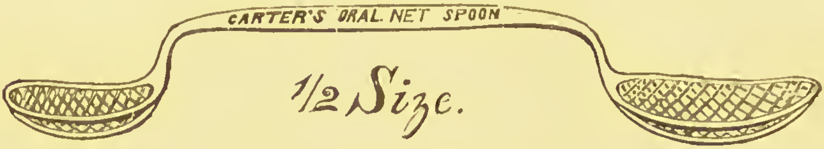

FIG. 10.—Carter's Oral Net Spoon.

2. Remedies.—Various medicinal remedies have been advocated for the treatment of alarming symptoms during anæsthesia, and opinions are still divided as to their relative efficacy. But, as will be subsequently pointed out (Part III.), the establishment of a free air-way, artificial respiration, and inversion are of far greater value than any other restorative measures with which we are acquainted. The question nevertheless arises: are there any particular medicinal remedies which we should have by us before administering a general anæsthetic—remedies which may be relied upon for the treatment of threatening conditions? Recent researches (p. 313) have shown that **digitalis** and **strychnine** are most likely to be of service, and that **alcohol, nitrite of amyl, ammonia**, and **atropine** are of questionable utility. The anæsthetist who wishes to be thoroughly equipped for all emergencies would therefore do well to have with him a hypodermic syringe and some readily accessible preparation of digitalis and of strychnine. Brandy, which is of use in certain cases, would probably be sufficiently near at hand if required. (For further remarks on the various restorative agents which are commonly employed see Part III.)

E. THE CLOTHING OF THE PATIENT.

Patients who are about to inhale an anæsthetic, whatever that anæsthetic may be, should invariably be loosely but warmly attired.

In the case of nitrous oxide, persons are liable to think they are being placed to unnecessary inconvenience by being obliged to unfasten corsets, belts, collars, &c., but nothing should be permitted to stand in the way of such precautions being adopted. It does not follow that because a patient with a tightly-laced waist can take a full breath she will be able to breathe freely under nitrous oxide; indeed, the reverse is likely to be the case. Anything that constricts the waist or prevents free thoracic or abdominal movement should be loosened. The front of the dress, or the coat, as the case may be, should be unfastened. Collars, too, should be unbuttoned or removed. Not only may the collar be uncomfortable to the patient if his head should be thrown backwards, but it may interfere with the upward or downward movements of the larynx which usually occur during deep respiration. Corsets should always be unfastened. All these precautions are not only necessary because of their providing for free respiration, but they are desirable from another point of view. Should any unexpected respiratory embarrassment occur during anæsthesia, remedial measures can far more efficiently be carried out than when the patient is attired in constricting clothing.

In operations requiring a more or less protracted anæsthesia, the patient should be attired in a loose warm dressing-gown, or be well wrapped up in blankets or shawls. It is important that he should be kept as warm as possible, more especially if feeble or advanced in years. In most cases socks or stockings should be worn, and two or three blankets placed over the patient when he lies in position for the administration.[1]

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[1] As much warmth as possible is necessary in the case of patients who are about to be placed in the lithotomy position, and in those whose lower extremities are likely to remain uncovered for a considerable time. Mr. Buckston Browne, by a very simple plan, prevents the chilling which is likely to take place in many operations upon the male bladder or urethra. A pair of the patient's pants is taken and one leg, having been turned inside out, is passed through the other. A long double stocking results. Another pair of pants is now similarly treated. The two stockings thus formed are placed on the patient, and keep both legs very warm without interfering with the manipulations of the surgeon in the perinæal region. Ether tremor, and perhaps more serious troubles, are probably obviated by keeping the legs warm.

F. THE POSTURE OF THE PATIENT.

Every endeavour should be made to place the patient in as comfortable a position as possible. In ordinary surgical work, when an operating-table is used, it is a good plan to allow the patient to adopt any posture he may think fit; for he can readily be moved subsequently should occasion require. When the patient has no special wish in the matter it is best for him to lie upon his back with his head and shoulders slightly raised. Should the head be raised and not the shoulders, a cramped position will result, and one which is unfavourable to free respiration. The administrator should, if possible, stand immediately behind his patient. It is sometimes advisable, in the case of nervous individuals, to give the anæsthetic whilst they are in bed, and subsequently to move them to the table. This plan, however, should not be adopted as a general rule; for not only is it somewhat difficult to anæsthetise a patient who is lying comfortably in bed, but the shaking-up which he undergoes whilst being carried from one place to another is not unlikely to disturb good anæsthesia, and to induce vomiting. Whenever the patient has no objection it is far better for him to lie upon the table.

When the recumbent posture cannot be assumed without causing distress in respiration, the administrator should allow the patient to arrange himself in that position in which he breathes with the greatest ease. The sitting posture is a convenient one in dental surgery, and for many other short operations within the oral or nasal cavity. Nitrous oxide or ether may be given to patients in this position, but chloroform should not be employed.[1]

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[1] Although Snow administered anæsthetics to 949 patients in the sitting posture without any untoward results, experience has since established the fact that there is risk in this practice.

PART II.

THE ADMINISTRATION OF THE SELECTED ANÆSTHETIC.

CHAPTER I.

NITROUS OXIDE.

THERE is no necessity to refer at any length to the value of nitrous oxide as a general anæsthetic. The improvements which have taken place in the direction of rendering this agent more readily available for surgical purposes, the rapidity with which consciousness becomes destroyed during its inhalation, and the almost invariable absence of all unpleasant effects after the administration are weighty considerations in its favour. The anæsthesia which results from nitrous oxide, although in the vast majority of cases satisfactory and sufficient, is not so profound as that resulting from ether or chloroform. Even when a patient is as thoroughly anæsthetised by nitrous oxide as is possible, many reflex phenomena may still persist. Moreover, the anæsthesia from this gas, administered in the usual manner, is complicated by certain symptoms which are undoubtedly due to the want of free oxygen. Nitrous oxide *per se* can only be respired for a very brief period owing to the absence of oxygen, and it therefore follows that, whether used to produce its own special effects, or employed as a preliminary to ether, this peculiarity of nitrous oxide becomes as marked a feature of the administration as the anæsthesia itself.

It will be convenient to consider nitrous oxide under three sections.

Section 1. Nitrous oxide administered free from all oxygen;
Section 2. Nitrous oxide administered with air;
Section 3. Nitrous oxide administered with oxygen.

Section I.—Nitrous Oxide administered Free from Oxygen.

A. APPARATUS AND METHODS OF ADMINISTRATION.

Nitrous oxide is supplied by the manufacturers in iron and steel **cylinders** which contain the agent in a liquid state under considerable pressure.[1] Those yielding 50 gallons of gas are most commonly used ; but 25-gallon cylinders are preferable when, as is often the case, portability is a matter of consideration. 100-gallon cylinders are more adapted for hospital practice. Every cylinder is furnished with a label stating its weight when empty and when fully charged ; so that, when weighed, the quantity of nitrous oxide present may always be ascertained if desired. 7½ ozs. of liquid nitrous oxide will furnish about 25 gallons of gas. Full, or nearly full, cylinders may at once be known by the liquid sound which they emit when sharply tapped with

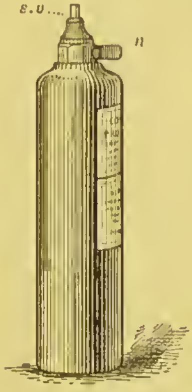

Fig. 11.—End-valve Nitrous Oxide Cylinder.

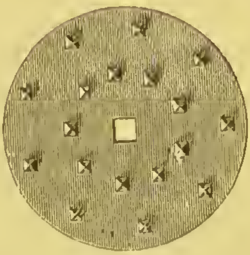

Fig. 12.—Foot-key.

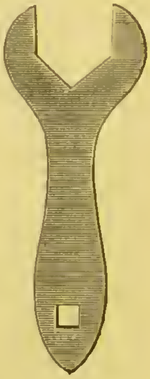

Fig. 13.—Hand-key and Spanner.

the foot-key, or some similar article. It is always advisable to have two cylinders coupled together, in case one should work badly or fall short during the administration. It is also a good plan to make it a rule on all occasions to work first from the bottle of one side, and only to go on with the second or reserve bottle in the event of the other becoming exhausted. If the administrator work indiscriminately from both bottles he may easily allow the supply of the anæsthetic to fall too low. Care should be taken to thoroughly turn off the gas after each administration, otherwise leakage will gradually occur and the cylinder become empty. Each cylinder is furnished with a screw-valve or tap, by turning which with a foot or hand-key, gaseous nitrous oxide escapes from the cylinder.

The cylinder most commonly used for the storage and supply of nitrous oxide is represented in Fig. 11. It will be seen that the screw-valve or tap (*s.v.*) which releases the imprisoned gas is at the end of the cylinder; whilst the nozzle or outlet tube (*n*) through which the gas escapes is at the side. We may therefore term this the end-valve cylinder, to distinguish it from the side-valve cylinder, to which reference will presently be made. End-valve cylinders may be worked either in the horizontal or in the vertical position, the latter being preferable when an equable supply of the gas is desired. Various kinds of foot-keys and hand-keys are in use for turning the screw-valve. Fig. 12 shows a **foot-key** with spikes. Fig. 13 shows a **hand-key** with a spanner at one end. The spanner is useful for connecting two cylinders together by what is known as a double union (Fig. 18, *du*), and also for attaching the single union (Fig. 18, *su*) of the tube leading to the inhaling apparatus.

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[1] I have been informed by one of the manufacturers of the gas that the pressure within the cylinders which they supply often registers nearly 1000 lbs. to the sq. in.

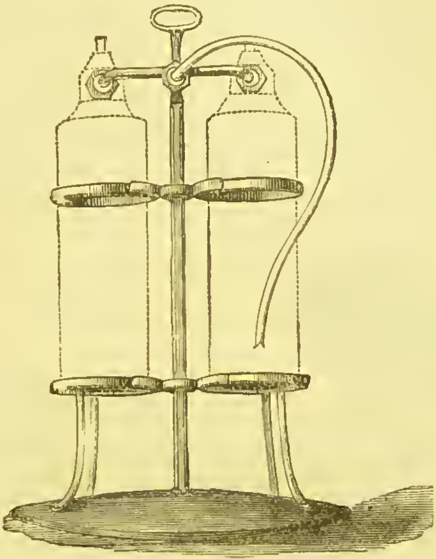
Fig. 14.—Napier's Stand for Two End-valve Cylinders of Nitrous Oxide.

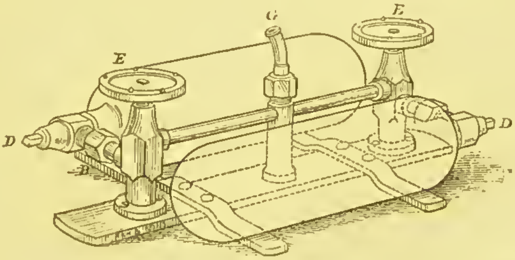

Fig. 15.—Stand (Weller's) for Two End-valve Cylinders of Nitrous Oxide.

Various kinds of boxes and **stands** are in use for fixing these end-valve cylinders whilst the gas is being released. Fig. 14 shows a form of stand which is still frequently employed. Fig. 15 represents a stand which allows of two end-valve cylinders being worked horizontally by means of foot-keys. I have had no experience with these stands, as the side-valve cylinders seem to me to have decided advantages over their predecessors. Still, given that end-valve cylinders are to be employed, the stand of Fig. 15 is as efficient as any. Before the apparatus is required for use, the gas is turned on at D, but is stopped at a second valve in the stand of the apparatus. This second valve, which works far more easily than that of the cylinder, is controlled by the foot-key (E).

Two side-valve cylinders coupled together with a double union are shown in Fig. 16. I have had a lengthened experience with these cylinders, and believe them to be better than any others. They have the great advantage that they require but a very simple form of stand to render them perfectly stable whilst being worked; and when fitted with the easily acting valves invented by Messrs. Barth & Co. they answer every requirement. When portability is a matter of great consideration two 25-gallon side-valve cylinders should be employed. It is only quite recently that these side-valve cylinders have been brought into a state of perfection. When they were first used they were not satisfactory; and to the late Dr. C. E. Sheppard belongs the credit of removing the objections which were formerly attached to their use. He found [1] that when nitrous oxide cylinders were worked

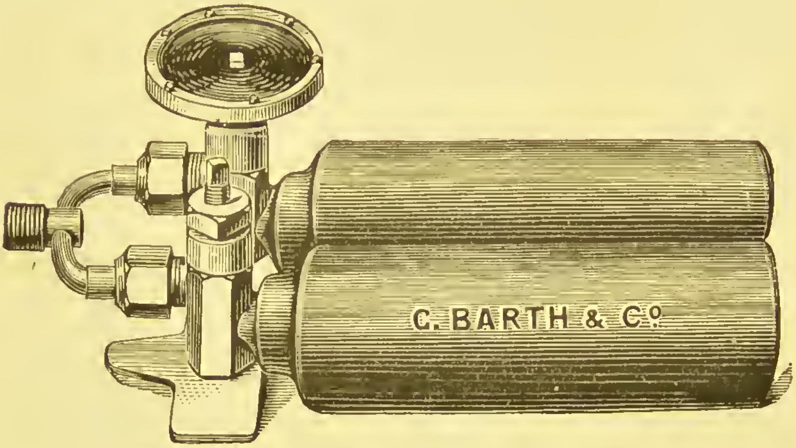

FIG. 16.—Two Side-valve Cylinders, with Stand, Double Union, and Foot-key.

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[1] See an interesting paper by Dr. C. E. Sheppard, *Lancet*, Feb. 21, 1891, p. 424: 'Difficulties connected with the Use of Nitrous Oxide Bottles in the Horizontal Position.' Dr. Sheppard found that the 50-gallon cylinders supplied by Messrs. Barth & Co. had a capacity of 50.5 cubic inches, and, taking the sp. gr. of the liquid to be .908 at 45° F. and the weight of the 50 gallons of nitrous oxide gas thus liquified to be 15 ozs., the space occupied in the bottle by the liquid was 28.6 cubic inches, roughly three-fifths of the total capacity. He argued that as the cold produced by the nitrous oxide passing from the liquid to the gaseous form is very intense, superficial solidification of the nitrous oxide may take place, and the snow-like body thus formed may temporarily choke the tube.

horizontally the outlet tube often became temporarily choked with liquid, or even solid nitrous oxide, owing to the inner orifice of the tube being at or below the level of the liquid. He suggested to Messrs. Barth & Co. that the inner end of the exit-tube should be bent upwards towards the upper wall of the cylinder, in order that its orifice might be well above the level of the liquid. By this simple device horizontal bottles may be made to work as freely as vertical.

Gasometers are sometimes employed for the storage of nitrous oxide, but it is hardly necessary to refer to their use in this work. Now that nitrous oxide is so readily obtainable, and now that we have cylinders which work so satisfactorily, there is less need for gasometers than was formerly the case.

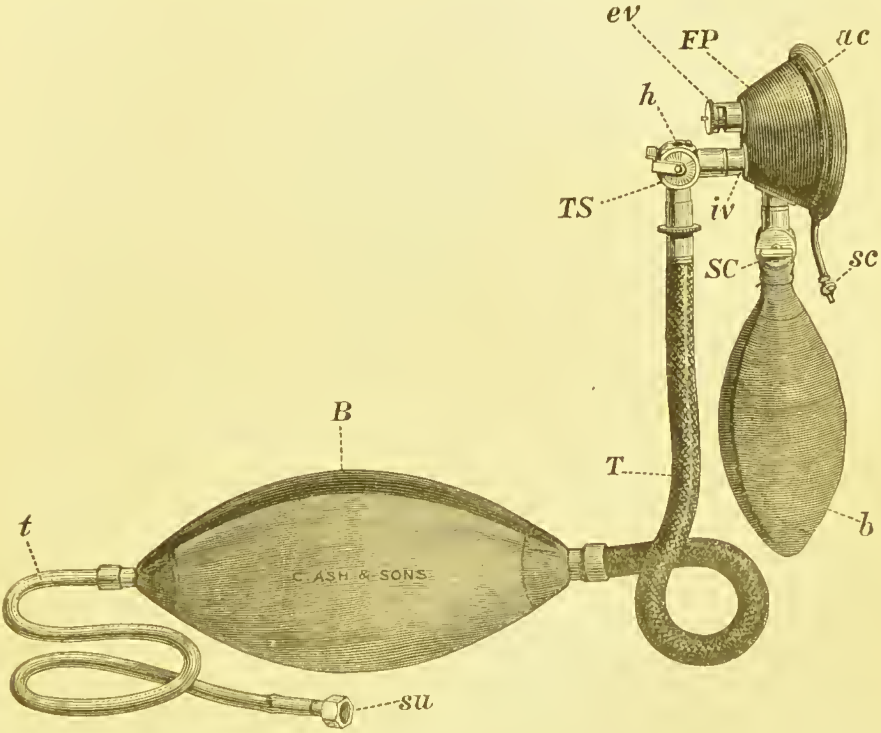

FIG. 17.—A Form of Nitrous Oxide Apparatus very commonly employed.

When two cylinders are used, they are connected by a brass tube known as a double union. (Fig. 18, *du.*) To this is attached a single union (Fig. 17, *su*) carrying the india-rubber tube (*t*), which conducts the liberated nitrous oxide to the gas-bag (B). The bag is often known as a Cattlin's bag. From B the gas passes by a wider tube (T) to the inhaling apparatus. This consists of three main parts—a two-way stopcock (TS), a face-piece (FP), and a 'supplemental bag' (*b*). The two-way stopcock has an air-hole (*h*) in it, so that either air or nitrous oxide may be breathed by the patient at the will of the anæsthetist. The face-piece possesses an india-rubber air cushion (*ac*), which may be inflated at the little stopcock (*sc*). It also possesses two circular horn valves working upon delicate spiral springs—one an inspiratory (*iv*), and the other an expiratory valve (*ev*). These valves prevent the re-breathing of nitrous oxide, and allow of the escape of the expirations into the surrounding air. The so-called 'supplemental bag' (*b*) is a small bag which is attached to the lower part of the face-piece, and is separated from the latter by a stopcock (SC). This bag was introduced by Clover to meet those cases in which violent breathing occurred. When the patient breathed very forcibly he opened the stopcock of the 'supplemental bag'[1] in order to temporarily provide free channels for the deep respirations. The 'supplemental bag' is now rarely used.

The apparatus above figured is that which is still largely used for the administration of nitrous oxide, and for this reason I have described it in detail. Countless modifications have been made in it from time to time. Clover[2] himself found, for example, that he could get all the advantages of his 'supplemental bag' by dispensing altogether with an inspiratory valve in the face-piece. This necessarily simplified the apparatus, and many administrators now employ a face-piece with but one valve. In order that such an apparatus may be used successfully, the bag must be nearly or quite full at the commencement of the inhalation, so that the expirations may not pass back into it to any great extent. The expiratory valve will only act when the bag is kept distended. The bag may at any moment be made to play the part of the 'supplemental bag' already described, by stopping the supply of fresh nitrous oxide and placing the thumb over the expiratory valve. For reasons to be presently referred to, this plan of administering nitrous oxide is open to certain objections.

Some years ago[3] I made a special study of the various methods then in use for administering nitrous oxide. I came to the conclusions—(1) That accurately fitting valves were essential at the commencement of the inhalation, in order to make sure of the rapid exit of atmospheric air from the lungs; (2) that, so far as the available resulting anæsthesia was concerned, there was a decided advantage in allowing a certain amount of re-breathing of nitrous oxide towards the *end* of the inhalation; (3) that although there were certain hygienic objections to this re-breathing, it was nevertheless very convenient to be able to resort to it as a measure for securing a longer anæsthesia, or for successfully terminating an administration when the supply of nitrous oxide had unexpectedly fallen short. There was no apparatus which would allow of two valves being in action for the earlier or middle stages of the administration and would subsequently permit re-breathing. I therefore devised[4] and used a face-piece with thin rubber valves which could, at the will of the administrator, be thrown out of action, and allow of the gas-bag being used very much as Clover's 'supplemental bag' was used, *i.e.*, for to-and-fro breathing. Subsequently I placed these rubber valves in a little box between the stopcock and the face-piece,[1] so that plain valveless face-pieces could be attached. The valves were thrown into and out of action at will by turning a small handle surmounting the valve-box. A short trial of this apparatus led to my placing the valves and the two-way stopcock *in one chamber*, in other words, to the apparatus which I now employ, and which I believe to be better than all others for the administration of nitrous oxide (Figs. 18, 19, and 20).

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[1] *Brit. Med. Journ.*, Feb. 14, 1874.

[2] *Op. cit.*

[3] See 'An Enquiry into Several Methods of Administering Nitrous Oxide' (*Journ. Brit. Dent. Assoc.*, vol. vii. 1886, p. 86).

[4] *Lancet*, May 9, 1885.

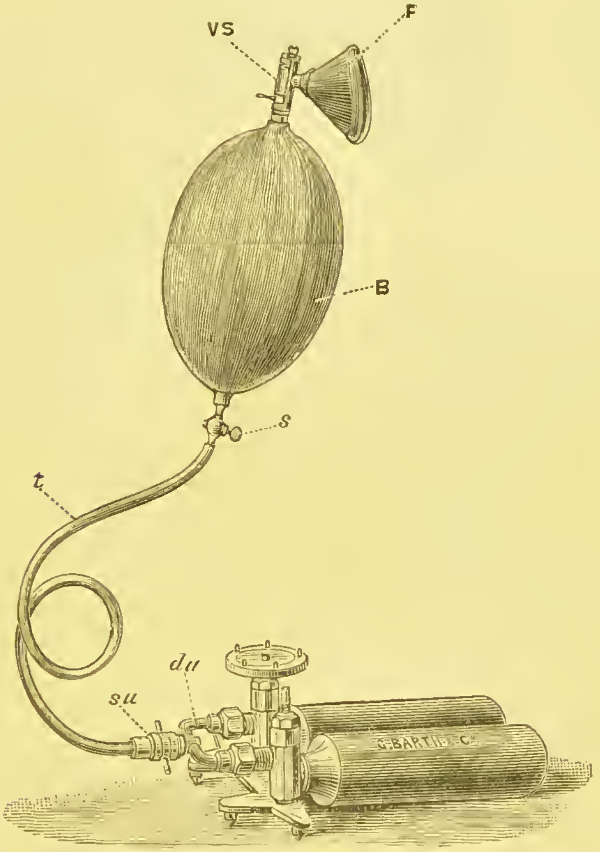

Fig. 18.—Complete Apparatus for the Administration of Nitrous Oxide Gas.

The apparatus which I have found to give the best results in the administration of nitrous oxide is shown in the accompanying figure. It is made for me by Messrs. Barth & Co. From the single union (*su*) the tube (*t*) passes to join the bag (B).[2] A little stopcock (*s*) is useful in case it should be wished to disconnect a full bag from the rest of the apparatus. The bag (B) has a capacity of from 2 to 2½ gallons.

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[1] See *Brit. Med. Journ.*, Aug. 27, 1887, p. 452.

[2] Some administrators interpose what is known as a 'quieter' between the gas cylinders and this tube, but when properly managed the noise of issuing gas is so slight as to render such a complication unnecessary.

There is certainly an advantage in having the bag as near as possible to the face-piece; for not only can its movements be readily watched, but the patient can take the most forcible inspirations without any of

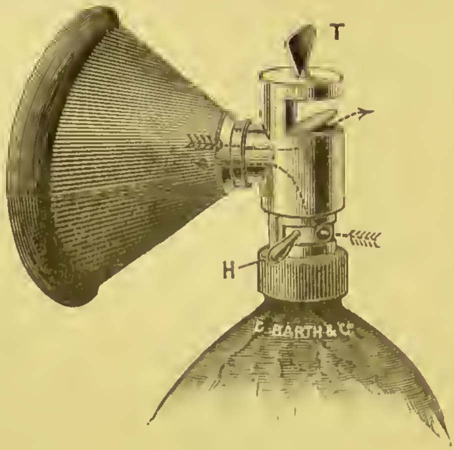

FIG. 19.—Valved Stopcock and Face-piece of Fig. 18.

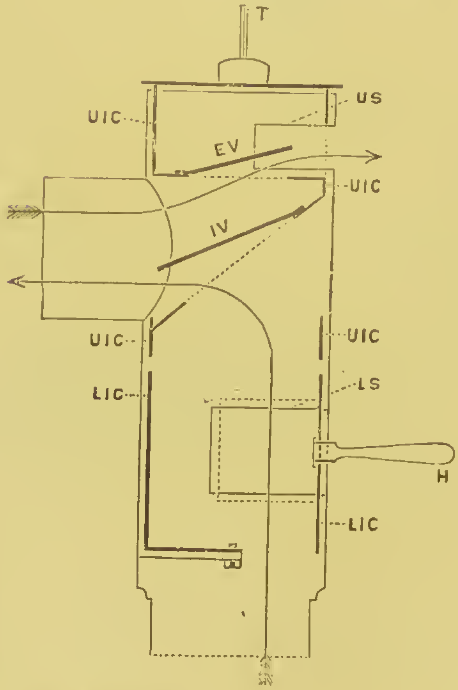

FIG. 20.—Diagrammatic Section of Valved Stopcock of Figs. 18 and 19.

that impediment which is likely to be experienced when a tube exists between the bag and face-piece. The valved stopcock (VS), which is the most important part of the apparatus, connects the gas-bag (B) to

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the face-piece (F). This stopcock, shown more in detail in Figs. 19 and 20, contains two thin valves of sheet india-rubber, which may be thrown into or out of action by turning the tap T. The handle H determines whether air or gas is admitted to the face-piece. When T and H are arranged as in Fig. 19, air enters the stopcock and is breathed out through valves in the direction shown by the arrows. Fig. 20 shows in diagrammatic section the mechanism of the valved stopcock. It has two slots cut out of its circumference, an upper slot (US) and a lower slot (LS). There are two inner cylinders which revolve immediately inside the outer casing of the stopcock. The upper inner cylinder (UIC) is worked by T, the lower (LIC) by H. The upper cylinder carries the inspiratory and expiratory valves (IV and EV). The lower has a slot in its walls (shown in dotted lines) which can be made to correspond with LS by turning H. When T is turned as in the diagram the upper slot is open, both valves act, and expirations escape as shown by the arrow. When T is turned completely round, the upper inner cylinder rotates, the valves are thrown out of action, the upper slot is closed (as shown by dotted line), and to-and-fro breathing results. Whether air or nitrous oxide is admitted to the face-piece is determined by the position of H. When H is placed as in the diagram the inner cylinder which it controls allows of a free passage of gas from the bag to the face-piece (as shown by the long arrow). Should H be moved round, the inner cylinder would cut off the way to the bag, and would open the air slot (LS), so that air and not gas would be respired (Fig. 19). The valved stopcock therefore permits :—

(1.) *Air* to be breathed { (*a*) *through valves*, or
(*b*) *backwards and forwards.*

(2.) *Nitrous oxide* to be breathed { (*a*) *through valves*, or
(*b*) *backwards and forwards.*

In actual practice we arrange the stopcock so that the patient may first of all breathe air through valves, and then nitrous oxide through valves; and we only call into play the to-and-fro breathing of nitrous oxide under special circumstances, to which future reference will be made. The arrows in Fig. 19 indicate the direction taken by the air current when the face-piece is applied to the face, *i.e.*, before nitrous oxide is turned on by the handle H. The valves should work easily. They should be examined before use to see that they do not stick and that they have in no way become caught in the orifices which they guard. The whole stopcock has wide channels through it, in order that respiration may take place freely. This is especially necessary with regard to the air-hole, in order that when the apparatus is applied to the face the patient may feel no impediment in filling his chest with air. Many forms of apparatus have channels far too small for successfully administering nitrous oxide gas. The face-piece should be furnished with a broad soft air cushion, which should be partly distended with air by means of the little tap for the purpose. Two or three sizes are necessary. The angle of the face-piece cushion, into which the bridge of the nose fits, should be acute, in order that the face-piece may accurately fit the patient. No apparatus can be considered satisfactory unless it allows the patient to *breathe air through valves* before nitrous oxide is turned on. The reason for this statement will be presently discussed.

In **administering nitrous oxide** the following directions must be borne in mind.

1. *Make sure that there is a sufficient supply of gas before commencing.* As already stated, two cylinders should be connected together in case one may fall short or work badly. Patients vary as to the quantity of nitrous oxide required to produce anæsthesia. The average may be roughly placed at six gallons per patient. Tall and well-built men, alcoholic subjects, and patients addicted to opium or chloral, may require considerably more than this. When there is much hair around the mouth it is often difficult to wholly exclude atmospheric air, and hence more nitrous oxide than usual may be needed. In such cases it is a good plan to moisten the moustache or beard before applying the face-piece, and to keep up a greater pressure than usual within the gas bag. Anæmic and feeble subjects, as well as children, may usually be anæsthetised by three or four gallons of the anæsthetic.

2. *Run a small quantity of nitrous oxide through the apparatus to free it from air: fill the bag to about two-thirds with the gas: and then turn off the screw-valve of the bottle.* The apparatus is now charged and ready for use. All the above arrangements should if possible be made out of sight of the patient.

3. *Breathe through the face-piece in order to make sure that the valves are acting efficiently.*

4. *Adjust the mouth-prop, should one be necessary* (see p. 45).

5. *Gently apply the face-piece to the face of the patient.* Success in giving nitrous oxide largely depends upon the accuracy with which the face-piece fits. The best test as to the fitting is the soft regular sound made by the valves. It is usually a good plan to tell the patient that he is simply breathing air, and to request him to take "long deep breaths, in and out, through the mouth." Should the face-piece not fit well, the particular sound made by the particular apparatus when its valves work freely, and when it fits the face, will not be produced; and the face-piece must be re-adjusted. Never turn on nitrous oxide till it is quite certain that the face-piece fits, and that the patient is breathing air freely through the apparatus. Some patients hold their breath and pretend to be breathing deeply when in reality they are not doing so. Unless the patient can be made to freely fill his chest with air he certainly will not inhale nitrous oxide when the latter is substituted. The administrator may often get a patient

to breathe freely by showing him how to respire. Upon this free breathing success greatly depends, so that it should be a rule not to proceed till patient breathes in a proper manner.

6. *When the patient is observed to be freely filling his chest with air through the apparatus, nitrous oxide should be turned on.* At the moment that this is done the gas-bag should not be over-distended: it should be about two-thirds full. In some forms of apparatus now made, the patient, in the first instance, breathes air *in and out* through a slot and not through valves. All such forms of apparatus are constructed on erroneous principles. The transition from air through valves to gas through valves is hardly noticed by the patient; the same sound is made and the same feelings are experienced in filling the chest. But if a patient is first allowed to breathe air in and out through a slot, and is then made to breathe nitrous oxide through valves, the transition is more noticeable to him, and more likely to disturb his breathing.

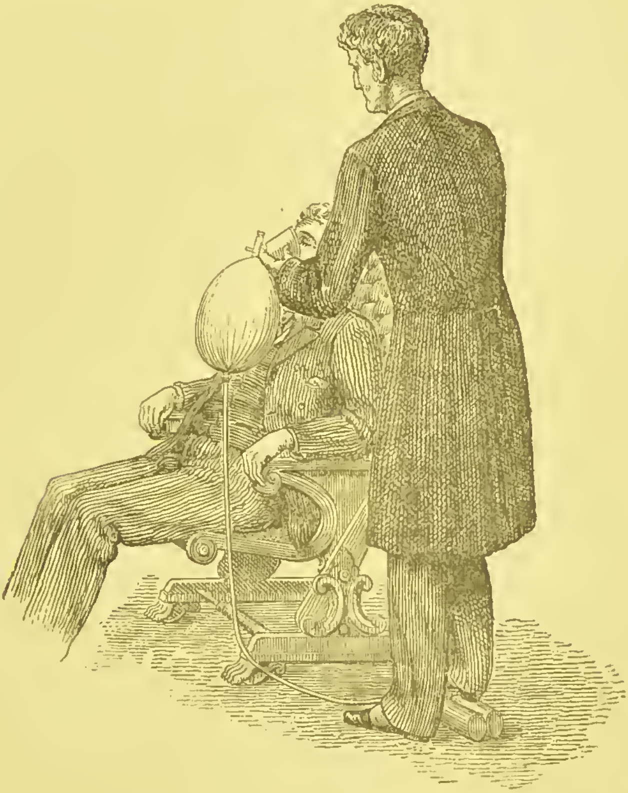

FIG. 21.—The Administration of Nitrous Oxide for a Dental Operation (from a photograph).

7. *The bag should be kept nearly full throughout the administration.* At the same moment that nitrous oxide is admitted to the air-passages of the patient, the administrator should gently allow a stream of gas to enter the bag from the bottle. Fig. 21 shows the administration of nitrous oxide for a dental operation by means of the apparatus which I find to answer best. By a little management hardly any noise need be made by the gas issuing from the gas cylinders. Should it be necessary to let in so much gas from the cylinder that more noise than usual results, the patient will by that time be unable to hear it. An attempt should be made to give the gas as nearly as possible slightly above atmospheric pressure. Any evidence of excitement should be followed by a slight increase in the pressure of the bag, as such symptoms are probably due to the ingress of air by the side of the face-piece. In the case of tall strong men it is best to keep up a slight positive pressure throughout; whereas in weakly patients and children the reverse plan may be followed. Increased pressure in the gas-bag probably only affects the administration in so far that it prevents the smallest quantity of air gaining admission with the gas, whilst with diminished pressure a small percentage of air probably obtains admission. It is, at all events, certain that whilst a small quantity of air is prejudicial to a successful anæsthesia in vigorous subjects, such a dilution of the gas is often advantageous in fragile persons and children (see p. 113).

8. *To-and-fro breathing of nitrous oxide should not be permitted except under certain circumstances, and then only towards the end of the administration.* A great deal of discussion has taken place as to the propriety of allowing the patient to re-breathe nitrous oxide during the administration. The matter admits of consideration from two points of view, which may be called (*a*) the hygienic, and (*b*) the practical. From the hygienic point of view, we must all admit that, as a routine procedure, the re-breathing of nitrous oxide is not to be recommended. It is next to impossible to thoroughly cleanse nitrous oxide bags after every administration; and we are certainly not justified, whatever may be the advantage of the plan, in allowing one patient to inhale from a bag into which another one has just been breathing. From the practical point of view, however, the question assumes a totally different aspect. I am not referring to to-and-fro breathing *early* in the administration; this is, of course, inadmissible by reason of the dilution of nitrous oxide which would result from its admixture with the considerable proportion of atmospheric air previously contained in the air-passages of the patient. I refer to to-and-fro breathing towards the *end* of the administration, *i.e.*, when most

of the air has been washed out of the air-passages of the patient by the free inhalation and exhalation of nitrous oxide through valves. For the sake of clearness let us suppose that we have six gallons of nitrous oxide ready for an administration. We allow the patient to breathe four gallons of this through valves, so that his lungs rapidly lose nearly all the air which they contained, and all expirations escape into the surrounding atmosphere. The valve-action is now stopped, and the patient is made to breathe the remaining two gallons of nitrous oxide backwards and forwards into the bag. Anæsthesia will take a little longer to become established than usual, because of a small percentage of oxygen (probably from the residual air of the lungs) being still in the to-and-fro current. Had no to-and-fro breathing been permitted, the phenomena of nitrous oxide anæsthesia would have come on earlier, because of the quicker expulsion of all oxygen. Now, the longer inhalation leads to a longer anæsthesia, so that from some points of view this plan of administering nitrous oxide has distinct advantages. That the re-breathing *towards the end of the administration* has no bad effect upon the patient I have proved by a very large number of administrations. I have found, it is true, that the recovery is not quite so rapid as when nitrous oxide is continuously inhaled in the usual manner; but this slight difference is connected with the longer period of inhalation. The longer we allow a patient to inhale an anæsthetic, the longer, as a rule, will he be in regaining complete control and consciousness. Some have objected that this method of re-breathing towards the end is more 'asphyxiating' than the ordinary method. But the reverse is probably more correct if by asphyxiating is meant the occurrence of symptoms dependent upon the deprivation of oxygen. Were it not, therefore, for the hygienic objections above alluded to, the plan of administering nitrous oxide just described would certainly have advantages over others.[1]

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[1] I have analysed the contents of the gas-bag, at the end of an administration, after to-and-fro respiration, and have found from 1.2 to 2.4 per cent. of oxygen in a two-gallon gas-bag which, from the moment when to-and-fro breathing commenced to the termination of the administration, remained full or nearly full. Full details of the experiments are given in the *Journ. Brit. Dent. Assoc.*, vol. vii. 1886, p. 86. I have administered nitrous oxide to a patient on six different occasions. On three of these I adopted the ordinary method, allowing the valves to act throughout, and all expirations to escape. On the three other occasions the patient was anæsthetised by allowing her expirations for the first and major part of the inhalation to escape, and then, when the lungs had been well washed out with gas, to-and-fro breathing was permitted. The times (*a*) of inhalation and (*b*) of resulting anæsthesia were taken on each occasion, and are of much interest as showing the slight but distinct gain in available anæsthesia when to-and-fro breathing is permitted towards the close

B. THE EFFECTS PRODUCED BY NITROUS OXIDE WHEN ADMINISTERED FREE FROM OXYGEN.

Owing to the rapidity with which the phenomena of nitrous oxide narcosis make their appearance, there is greater difficulty in arranging them into groups, and in recognising degrees or stages in the administration, than in the case of ether or chloroform. But from the fact that nitrous oxide, more particularly when administered with oxygen, closely resembles ether and chloroform in other respects, it has been thought best to adopt the same plan that will be followed when describing the phenomena which attend the administration of the last-named agents. In order that comparisons may be drawn between nitrous oxide on the one hand and ether or chloroform on the other, we must either disregard as not bearing upon the question those phenomena which in the case of nitrous oxide administered *per se* are dependent upon temporary absence of oxygen, or, better still, we must compare the anæsthesia of nitrous oxide *plus* oxygen (see p. 126) with the anæsthesia of agents which are also administered with this gas, *i.e.*, with atmospheric air.

First Degree or Stage.—Nitrous oxide has a peculiar sweetish taste which is by no means unpleasant. Great variation will be found to occur in the sensations which patients experience during the inhalation of this agent. When administered in the proper manner, and with due attention to details, these sensations will be more likely to be of an agreeable than of a disagreeable character. Should the apparatus possess valves which do not work easily, or should the channels through which the gas is made to pass be too small, or should the patient from want of confidence or knowledge breathe in a shallow and restrained manner, an unpleasant experience may be the result. A feeling of warmth in the lips, and an indescribable though pleasant numbness over most of the body, are amongst the first sensations noticed. The patient has an irresistible desire to breathe more deeply and quickly. These sensations are rapidly followed by a peculiar and pleasurable 'thrilling' which hardly admits of description. Almost identically the same sensations mark the first stage of chloroform inhalation. Some tinnitus may be present, and curious sensations, such as fulness and expansion of the head, are occasionally experienced. As a general rule, how-

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of the administration (see *Journ. Brit. Dent. Assoc.*, vol. vii. 1886, p. 342). The average available anæsthesia in the absence of to-and-fro breathing was 39 seconds: whilst when to-and-fro breathing was permitted, as described, a workable anæsthesia of 56 seconds was obtained.

ever, loss of consciousness comes on before the patient has time, so to speak, to define his feelings. The respiration will be observed to be deepened and quickened in response to the desire of the patient just alluded to. The pulse, as Sir George Johnson has pointed out, grows fuller under the finger; and, according to my experience, is invariably quicker than before the administration. The time which elapses between the commencement of the inhalation and loss of consciousness is extremely short, being probably about 10–15 seconds on the average.

Second Degree or Stage.—With the loss of normal consciousness, disturbed psychical states are liable to arise. As a general rule the patient gives little or no evidence of such disturbance, more especially if allowed to remain perfectly quiet. If roughly handled he is liable to become excited and to move his arms or legs. When nitrous oxide is properly administered symptoms of excitement are, with the rarest possible exceptions, conspicuously absent. Any injury inflicted during this stage would produce immediate reflex effects, such as shouting, co-ordinate, or inco-ordinate movement, but would not be accurately remembered by the patient. Nitrous oxide is often accused of producing imperfect anæsthesia, because operations are sometimes commenced at this stage. Dreams are frequent, but are rarely distinctly remembered. Sometimes they are so pleasant that, at the conclusion of the administration, the patient, who is unaware of having been deeply anæsthetised, is sorry to be disturbed. On other occasions dreams are of the most disagreeable character. It is a curious fact that unpleasant dreams are more common under nitrous oxide *per se* than under nitrous oxide administered with oxygen—probably because the anæsthesia in the latter case is deeper, so that operations or other interferences which in the case of nitrous oxide itself might leave some disturbed impressions, are not capable of doing so when the narcosis is more profound. Erotic dreams are occasionally experienced.[1] The respiration is still quicker and deeper than normal, and save perhaps for an occasional act of swallowing, is perfectly regular. In some cases a spurious form of stertor may occur and is to be disregarded. The pulse is still full and a trifle quicker than in the previous stage. The conjunctiva is quite sensitive to touch. The pupils usually grow larger as the administration proceeds. The features gradually lose their normal colour. Duskiness or lividity is most common in patients of a florid type, anæmic and sallow persons showing very little alteration in appearance. The eyelids are usually affected by slight twitching; and as the inhalation proceeds they exhibit a tendency to separate and to display the subjacent globes.

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[1] See *Lancet*, vol. ii. 1872, p. 721.

Third Degree or Stage.—The first indication that the patient is passing or has passed into the third stage of anæsthesia is usually afforded by the **respiration**. The breathing, which has hitherto preserved its rhythm, now loses it, and a peculiar and characteristic throat-sound, sometimes described as 'stertor,' becomes audible.[1] This sound is most probably due to irregular and spasmodic elevations of the larnyx towards the epiglottis and base of the tongue, and indicates a tendency to obstruction in the air-way at this point. Deep snoring or snorting breathing may be met with in certain cases, and may either necessitate the withdrawal of the anæsthetic before the time has come, so to speak, for the deeper throat-sound, or may altogether mask the latter. As will subsequently be pointed out, the position of the head and the conformation of the upper air-passages will have an important bearing on the presence or absence of stertor. At or about the moment at which the characteristic guttural sound occurs, the rhythm of breathing is liable to be further interfered with by clonic spasm of thoracic and abdominal muscles. Sometimes, indeed, a sudden irregularity in breathing, totally independent of laryngeal closure or 'stertor,' and entirely the outcome of this muscular spasm, may be the first indication of deep anæsthesia. It occasionally though rarely happens that, instead of respiration undergoing the changes mentioned, it becomes somewhat feeble; or expiration becomes prolonged and rather stridulous. These phenomena should, in the presence of other signs of anæsthesia, be taken to mean that the administration has been pushed sufficiently far, and air should be admitted. I have found by timing 60 consecutive cases of nitrous oxide administrations that the average number of respirations required to produce deep anæsthesia was 29.2. The lowest recorded number was 6; the nighest 72. It need hardly be pointed out that it is very exceptional for deep anæsthesia to follow after only six inspirations of the gas; but the number is quoted in illustration of the fact that a very small quantity of this, as of other anæsthetics, is sometimes needed in order to produce the usual phenomena.

The **circulation** is well maintained during nitrous oxide narcosis, provided that care is taken to prevent too great a degree of asphyxiation. From the observation of a considerable number of cases I have found that, in most instances, the heart's action becomes more and more accelerated as the administration proceeds, and that, when the usual phenomena of nitrous oxide narcosis occur, the pulse is often very rapid, especially in those whose cardiac action was quick at the commencement of inhalation. A pulse of 120 immediately before the administration may, for example, rise to 160 or more when clonic movements, &c., occur; whereas a pulse of 80–90 at the beginning of the inhalation will often not exceed 100 or 110 in the third stage. As the pulse increases in frequency it loses, to a certain extent, its previous fulness; and this change is of course most conspicuous in patients with quick cardiac action. Immediately air is admitted by the withdrawal of the anæsthetic, the pulse undergoes a marked change. It at once becomes slower and fuller. A pulse of 140 at the acme of anæsthesia may thus suddenly drop to about 80 per minute before the effects of the anæsthetic have passed off. As consciousness becomes restored, the pulse-rate again rises, being influenced by mental conditions, after-pain, &c.

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[1] The word 'stertor' should, I think, be confined to *snoring* sounds.

With regard to the **muscular phenomena** considerable variation exists. The extremities are usually, though by no means invariably, flaccid. When respiration undergoes the changes above referred to, the arm, if raised by the administrator, will generally fall. But there is a tendency, when nitrous oxide has been administered to its fullest extent, for clonic muscular contractions to occur in all cases, and for tonic spasm to arise in many. Clonic movements of the extremities, to which the word 'jactitation' is often applied, are extremely common. They usually manifest themselves at or about the moment at which respiratory rhythm becomes altered. There is little doubt indeed that the intermittent elevation of the larynx, the irregular contractions of the thoracic and abdominal muscles, and the clonic movements of the extremities are correlated, and of the same origin. Tonic muscular contraction is sometimes very pronounced, not only in the extremities but in the neck, back, and other parts; some patients, indeed, pass into an opisthotonic condition during this stage. Micturition very rarely occurs, but is sometimes met with in children when the clonic movements are at their height. Defæcation is extremely uncommon. Prof. Victor Horsley has shown[1] that in deep nitrous oxide narcosis the superficial plantar reflex is abolished, but the deep patellar reflex is maintained. Eulenburg's experiments[2] also show that in the asphyxial state, whether induced mechanically or by drugs such as nitrous oxide, the superficial reflexes disappear before the deep. Dr. Buxton[3] found that one-third of the men, and nearly one-third of the women, anæsthetised by him at the Dental Hospital, displayed ankle-clonus under nitrous oxide.

[1] *Brain*, vol. vi. p. 369.
[2] *Centralblatt für Med. Wissensch.*, No. 6, 1881.
[3] *Brit. Med. Journ.*, September 24, 1887.

The **pupils** in the majority of cases are dilated in deep nitrous oxide anæsthesia. In some cases, even though the anæsthetic has been freely administered, they remain of moderate size or even contracted.

The **lid-reflex**, which will have persisted during most of the administration, now either becomes less marked or disappears. It cannot be depended upon as a guide, for it may sometimes be elicited even when wide dilatation of the pupils, and other signs indicative of the anæsthetic having been pushed as far as is advisable, are present.

The **colour of the features** is invariably altered, the change being most noticeable at the height of the muscular phenomena. Flabby and apoplectic-looking patients usually become deeply cyanosed when fully anæsthetised by nitrous oxide.

C. TIME TAKEN TO PRODUCE DEEP ANÆSTHESIA.

The time taken to produce deep anæsthesia varies considerably in different subjects.[1] By timing forty consecutive cases, men, women, and children, at the Dental Hospital, I obtained the following results:—

Maximum period of inhalation	70 *secs.*
Minimum . ,, ,, ...	25 ,,
Average . ,, ,, ...	51 ,,

If the bag from which the gas is being inhaled be kept slightly distended, anæsthesia will ensue more rapidly than if the supply of the anæsthetic be less freely maintained. This is probably owing to the impossibility of any atmospheric air gaining admission to the lungs whilst a positive pressure is being kept up in the gas-bag. We should endeavour to administer nitrous oxide as nearly as possible at atmospheric pressure, neither allowing the bag to become too much distended, nor permitting it to become so nearly exhausted as to cause a slight exertion on the part of the patient in drawing out the gas from the bag.

Children and anæmic patients may sometimes be deeply anæsthetised in 15 or 20 seconds; whereas, in the case of robust and vigorous subjects, the administration may have to be carried on for from 1 to 2 minutes before signs of deep anæsthesia are witnessed.

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[1] Dr. Silk, in his work on nitrous oxide, p. 66, says, "The Odontological Committee places the average for men, women, and children at 73.3 secs.," and he himself in eleven cases found the average period to be 68.8 secs. I cannot help thinking these figures are a trifle too high when atmospheric air is stringently excluded and the valves of the apparatus work accurately.

D. AVAILABLE PERIOD OF ANÆSTHESIA AFTER INHALATION.

The available period of anæsthesia after the withdrawal of the anæsthetic varies from a few seconds to two minutes. By timing 40 consecutive cases at the Dental Hospital I arrived at the following results:—

Maximum period of anæsthesia after inhalation .	65 *secs.*
Minimum ,, ,, ,, .	20 ,,
Average ,, ,, ,, .	42.1 ,,

Subsequent experience has led me to believe that 42 secs. is rather too high an average, and that 35 secs. is probably more correct as a workable average. There is considerable difficulty in deciding when true anæsthesia actually terminates, and this no doubt accounts for the discrepancies in the statements made by various authors. The period of available anæsthesia is to a certain extent dependent upon that of the inhalation; a long inhalation being followed, as a general rule, by a long anæsthesia, and *vice versâ.* Moreover, in dental operations the duration of anæsthesia will not infrequently be found to be influenced by the position of the patient's head, and more especially by the position of his tongue, during the extraction of the teeth. Should the head be fully extended and the operation upon the upper jaw, nitrous oxide will have every chance of quickly escaping, and consciousness may thus be rapidly regained. If, however, the head be more or less vertical in the chair and the operation upon the lower jaw, nitrous oxide may not escape so freely; either by reason of the tongue being slightly pressed backwards, or from the lower jaw being so driven down upon the sternum that the epiglottis temporarily obstructs respiration and so favours the retention of the anæsthetic within the lungs.

E. DANGERS CONNECTED WITH THE ADMINISTRATION.

The inhalation of nitrous oxide is, in the hands of those accustomed to its use, practically free from all risk. It is necessary, however, to make some reference not only to the symptoms which would attend an over-dose of this agent, but to certain other remote dangers.

1. The Administration of an Over-dose: Fourth Degree or Stage.—In moderately healthy subjects the persistent administration of nitrous oxide causes arrested breathing before indications of grave cardiac depression occur. With the cessation of respiration the pupils become widely dilated, the eyes upturned, and the features of a pronounced livid hue. Clonic muscular phenomena may now occur for the first time, or, if previously present, may continue. Micturition or defæcation may take place. The immediate cause of failure of breathing appears to be spasmodic contraction of muscles directly or indirectly concerned in maintaining free respiration. As indicated above there is, even in ordinary practice, a slight tendency towards obstructed breathing; but immediately air is admitted by the removal of the face-piece all such tendency subsides. Should atmospheric air be withheld, in other words, should the administration be continued beyond the proper limit, breathing will cease, from obstruction at the superior aperture of the larynx, from spasm of the respiratory muscles, from actual paralysis of the thoracic and abdominal movements, or from more than one of these causes. By carefully watching the respiratory phenomena which accompany deep anæsthesia from nitrous oxide, it would seem fairly certain that, were the administration of this gas to be pushed to a lethal degree, respiration would, in most instances, come to a standstill from obstruction and spasm rather than from primary paralysis of respiratory muscles. We occasionally meet with a very feeble form of respiration under nitrous oxide; but not in moderately healthy persons. The latter usually if not invariably show a distinct tendency to obstructed or spasmodic breathing when nitrous oxide is pushed to its fullest extent. Whatever may be the immediate cause of respiratory failure under nitrous oxide, the all-important fact remains that breathing always shows signs of cessation before the circulation is arrested. The length of time the heart would hold out against these asphyxial symptoms would depend to a great extent upon its previous nutrition and strength. In the case of young and vigorous subjects experience shows that a comparatively long period of suspended breathing elapses before the heart's action becomes seriously depressed; whereas, in debilitated or flabby subjects, with dilated, fatty, or feeble hearts, any prolonged interference with respiration would much more quickly lead to final cardiac arrest.

2. The Passage of Foreign Bodies into the Larynx or Trachea during Anæsthesia.—This danger acquires special importance in connection with nitrous oxide when used for dental operations (see Part III. Chap. II., p. 296).

3. Respiratory Failure occurring independently of the Causes referred to in 1 and 2.—Loud snoring stertor, such as that commonly met with in florid and stout patients, and due to the base of the tongue coming in contact with the pharynx, may pass into obstruction, which can be relieved by pushing the lower jaw forwards, hooking the base of the tongue forwards, or actual tongue traction. The jaws may become clenched, and breathing suspended (p. 22). The senile and morbid changes which predispose to respiratory embarrassment under nitrous oxide have already been considered when discussing "The general condition of the patient" (Part I. Chap. II.).

4. Circulatory Failure: Syncope.—There is every reason to believe that moderately healthy persons under nitrous oxide are not liable to syncope, except as the result of respiratory difficulties. I have been unable to find any reliable account of grave or fatal syncope from imperfect anæsthesia under nitrous oxide; and when we remember that hundreds, and possibly thousands of patients are daily subjected to dental operations, whilst in the first and second degrees of anæsthesia, it is probable that the risk of syncope from this cause has, in the case of nitrous oxide, been over-estimated. The liability to cardiac failure in patients with feeble circulation, cardiac disease, and allied states, has already been considered (Part I. Chap. II., p. 25. See also Illustrative Case, No. 42, p. 321).

Extremely few fatalities have arisen in moderately healthy persons, from the direct effects of nitrous oxide. When we reflect that this agent has now been used in millions of cases, and that it is constantly being administered by unqualified persons, to patients of all descriptions, we cannot but be struck by its marvellous safety as an anæsthetic. When the inhalation of this gas has been followed by death, there has usually either been some mechanical interference with respiration prior to the administration, or the circulatory apparatus of the patient has been so seriously disorganised that, during the strain imposed upon it by a too prolonged or incautious inhalation, the heart has failed.[1]

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[1] See a case reported in the *Brit. Journ. of Dent. Scien.*, October 15, 1889, p. 924. Patient æt. 71, stout and flabby. Corsets not loosened. Stomach contained food. Syncope probably arose in the following manner. (1.) Heart feeble and fatty. (2.) Venous system became engorged, and especially the right side of the heart, during the administration. (3.) Patient unable to freely respire by reason of tight-lacing. (4.) When anæsthetic withdrawn, cardiac failure from combined causes.

For another fatal case see *Trans. Odont. Soc.*, vol. v. New Series, 1873, p. 83. Patient suffered from enlarged tonsils and uvula. Asphyxial symptoms after inhalation probably due to increase in the size of tonsils and adjacent parts (see Part III. Chap. II. p. 287 of this book). For other cases see also *Brit. Journ. Dent. Scien.*, February 15, 1885, p. 164; *Trans. Odont. Soc.*, vol. ix. 1877, p. 218; *Lancet*, June 28, 1890, p. 1451; and *Journ. Brit. Dent. Assoc.*, October 1880, p. 504.

F. THE DEPTH OF ANÆSTHESIA NECESSARY FOR SURGICAL OPERATIONS.

Although nitrous oxide usually produces anæsthesia of sufficient depth for the satisfactory performance of brief surgical operations, we cannot always depend upon that freedom from reflex movement and phonation which in the case of ether or chloroform invariably characterises the third degree of inhalation. Anæsthesia may be said to be at its height when any irregular twitchings, either in the respiratory muscles or elsewhere, make their appearance; and it is, as a general rule, necessary to push the administration to this point, before removing the face-piece for the operator to commence. Should the peculiar and characteristic gulping sound already referred to come on before obvious muscular twitching, it should likewise be taken to mean that the patient is ready for the operation. A snoring stertor coming on early in the inhalation should be disregarded, unless it tends to increase, and to pass into an obstructed form of breathing; in which case the operation must be permitted to commence. In one or two cases I have known prolonged and somewhat difficult expiration to replace other signs of narcosis. I have, moreover, met with cases in which just at the acme of anæsthesia, the patient has made a sudden attempt at retching. Under such circumstances as these, the administration should be discontinued. Any marked feebleness of the pulse or respiration should also be taken as an indication to remove the inhaler. Dilatation of the pupils is usually present in deep nitrous oxide anæsthesia, though it cannot be relied upon as a guide.

It is very desirable that the deepest possible anæsthesia should be present for surgical operations under nitrous oxide. Although the extraction of a tooth during imperfect anæsthesia may not give the patient the sensation which we call pain, the operation may, under such circumstances, produce such a horrible and ill-defined feeling, or give rise to such an unpleasant dream, that it is questionable whether the patient has gained anything by the inhalation of gas. In addition to these considerations the performance of an operation during imperfect anæsthesia may be attended by much inconvenient tonic muscular spasm, which in dental surgery is objectionable from the liability of extracted teeth, &c., to fall backwards during opisthotonus. Some authorities, moreover, maintain that a distinct risk of reflex syncope results from the performance of an operation during partially complete anæsthesia.[1]

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[1] See Dr. Buxton's work on Anæsthetics, p. 39.

Amongst the signs of returning consciousness may be mentioned—re-appearance of the normal colour of the lips and cheeks; reflex dilatation of the pupil (should the operation be going on);[1] and facial or other muscular movements indicative of pain. So long as any duskiness of the features remains the operation may, as a rule, be continued.

When prolonged anæsthesia is required the anæsthetic may be re-applied from time to time as the patient tends to come out of the narcosis. As the anæsthesia from a dose of nitrous oxide lasts for about 30 secs., intervals for air of about 20 secs. may be allowed. Only a few breaths of the gas will now be needed at a time, for the patient will be found to become rapidly re-anæsthetised.

G. AFTER-EFFECTS.

One of the chief advantages of nitrous oxide is that, as a general rule, it leaves behind no after-effects whatever. But in order to secure this desirable result, the operation must be performed at the acme of anæsthesia, no re-breathing must be permitted, and every care taken to place the patient's mind at rest as much as possible. The shorter the time the patient has been under the anæsthetic, the more perfect, other things being equal, will the recovery be. Long inhalations, as from the accidental or purposive admission of air, or from the employment of methods involving a variable degree of re-breathing, are not infrequently followed by a corresponding tardiness of recovery, with transient **stupor**, or **headache**. A feeling of **numbness** ('pins and needles') in the extremities is not uncommonly experienced after an inhalation. **Nausea and vomiting** are extremely rare as after-effects, and usually result from the entrance of blood into the stomach during or after the operation. Although nitrous oxide rarely produces vomiting when given shortly after a full meal, the chance of sickness is certainly greater than under other circumstances. I have seen one case in which violent retching always followed the inhalation of the gas, no matter what precautions were adopted. A double administration of nitrous oxide will be liable to produce vomiting if any food be in the stomach; this is especially the case with children.

Hysterical outbursts, or transient states of hallucination and struggling, are sometimes met with after the administration of nitrous oxide, but are very exceptional when the gas has been properly given, and the operation performed during the acme of anæsthesia.

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[1] The dilatation occurring from a full dose of the anæsthetic passes gradually away when air is admitted; but a second dilatation of reflex origin, *i.e.*, due to the continuance of the operation, is common. As a rule one cannot depend upon more than a few seconds' anæsthesia after the pupils have become smaller from the admission of air

Protracted stupor, cataleptic states, hemiplegia,[1] and even **insanity**[2] have one and all followed the administration of nitrous oxide; but such sequelæ are exceedingly rare.

Temporary glycosuria and even **true diabetes**[3] are also said to have been produced by the inhalation of nitrous oxide; but the evidence in favour of such charges cannot at present be regarded as conclusive.

SECTION II.—NITROUS OXIDE ADMINISTERED WITH AIR.

The title to this section may cause some surprise, seeing that the rigid exclusion of air is, by most authorities, regarded as the chief essential to success in the use of nitrous oxide. The belief is current, indeed, that in the presence of air this gas has no anæsthetic effects. By carefully watching the various methods in use for administering nitrous oxide, I am led to the conclusion, however, that, either from some imperfection in the apparatus employed, or from some slight inaccuracy in the fitting of the face-piece, a small percentage of air frequently, and perhaps usually, obtains admission to the lungs during the inhalation of the gas. Mr. Woodhouse Braine has, I believe, often demonstrated the fact that excitement by no means necessarily follows the letting in of a breath of air occasionally during the administration. The symptoms met with when air is allowed to be breathed with nitrous oxide appear to be chiefly regulated by (1) the percentage of air employed, and (2) the general physique and strength of the patient. Nitrous oxide may be regarded as an anæsthetic which admits of dilution in some cases, but of no such dilution in others. Though there are numerous exceptions to the rule, we may say that, other things being equal, the stronger and more vigorous the patient, the stronger must the nitrous oxide be, and the more careful must we be to exclude air.

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[1] A curious case is reported by Dr. Ashford (*Amer. Journ. Med. Scien.*, New Series, vol. 57, 1869, p. 408). A girl of sixteen became insensible for two hours after the exhibition of nitrous oxide. Headache, dizziness, and left hemiplegia followed. Dr. H. C. Wood also refers to another case (*Brit. Med. Journ.*, Aug. 16, 1890, p. 385), which occurred in Philadelphia: "A gentleman arose from the dentist's chair after an inhalation of nitrous oxide, staggered, and fell in an apoplexy."

[2] See an interesting paper by Dr. Savage, 'Insanity following the Use of Anæsthetics in Operations' (*Brit. Med. Journ.*, Dec. 3, 1887, p. 1199), in which is mentioned the case of a young woman, a chronic alcoholic, and liable to hysterical attacks, who, after the extraction of teeth under nitrous oxide gas, was attacked by delirious mania, which lasted for three weeks and terminated in dementia. Dr. Savage regards the anæsthetic as the immediate cause of the attack.

[3] See *Brit. Med. Journ.*, August 16, 1890, p. 385.

Small quantities of air (1–5 per cent.) with nitrous oxide have very little or no effect in modifying the phenomena already described as belonging to nitrous oxide *per se*. Many patients may, in fact, be successfully anæsthetised by nitrous oxide mixed with as much as 12 per cent., or even more, of air. Strongly built and full-blooded persons are not such satisfactory subjects for what we may term diluted nitrous oxide, as children and patients of fragile build. The greater the percentage of air present, the longer will be the period of inhalation, and the less pronounced will be the cyanosis, stertor, tumultuous respiration, and clonic movements. Excitement, laughter, struggling, and other signs of imperfect anæsthesia will only be likely to occur if the percentage of air be too great in the particular case. Patients who are very quickly anæsthetised by nitrous oxide free from all oxygen, and who consequently remain a very short time under its influence, will sometimes be found to be better subjects for nitrous oxide diluted with a small percentage of air than for the undiluted gas. The presence of air permits a longer inhalation, and the latter leads to a longer anæsthesia. The symptoms often met with, when nitrous oxide is administered to patients with very bristly beards, deserve notice in this connection. In such cases it is very difficult to absolutely exclude atmospheric air, even though the face-piece employed be accurately adjusted. A long period of inhalation (due to a small proportion of air) results; the colour of the face never becomes so completely changed as with nitrous oxide alone; the clonic movements and characteristic respiratory phenomena of ordinary nitrous oxide narcosis are frequently barely perceptible; and the resulting anæsthesia is of longer duration than that usually produced. If care be not taken to exclude air as much as possible in such subjects, too much may gain admission, and thus lead to uncontrollable excitement and very imperfect anæsthesia. It is an interesting fact that anæmic persons may be rendered quietly and deeply unconscious by nitrous oxide with a percentage of air which in other patients would almost certainly produce excitement and struggling.

Mr. George Rowell[1] believes that nitrous oxide administered with air gives better results in the majority of cases than nitrous oxide alone—a conclusion at which he has arrived after having adopted the method in more than 1000 cases. He gives air with gas by interspersing single inspirations of air amongst the breaths of gas, using my apparatus (Figs. 18, 19, and 20). The first breath of air is not administered until after from ten to twenty breaths of gas have been taken (according to the type of patient), when the stage of excitement has presumably gone by. He recommends that *some* air be given to all patients except (1) healthy and strong adult males, and (2) those patients, occasionally but rarely met with, who invariably display rigidity or considerable struggling under nitrous oxide. He urges that the resulting anæsthesia is usually of, at least, as satisfactory a character as when nitrous oxide free from air is given, and that it is of longer duration. In the vast majority of cases the extra time gained for operating is at least 10 secs., and often much more.

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[1] See 'On Some Points in the Administration of Nitrous Oxide' (*Journ. Brit. Dent. Assoc.*, October 15, 1892, p. 669).

But as a routine practice the admixture of air with nitrous oxide can hardly at present be regarded as advisable, save perhaps in the hands of experienced administrators. As already indicated, the tendency of those who have had but a short experience with nitrous oxide is to *unintentionally* admit air when administering the gas, so that any plan which depends for its success upon the *intentional* admission of small quantities of air might easily fail.

As an oxygenating agent air is, for reasons which will be presently discussed, very far behind oxygen. The supporters of the gas-and-air system do not, however, claim for it any great reduction in asphyxial symptoms.

SECTION III.—NITROUS OXIDE ADMINISTERED WITH OXYGEN.

Pure nitrous oxide cannot be inhaled for more than a brief space of time, owing to the deprivation of free oxygen which necessarily occurs during the administration. If the inhalation of the gas be carried beyond the proper limits, asphyxia quickly supervenes. Whilst all must admit the asphyxiating properties of nitrous oxide when pushed to an unnecessary and dangerous extent, there are some who deny the existence of symptoms referable to the want of oxygen when the gas is administered to the customary degree. But there is good ground for believing that certain of the symptoms which we are accustomed to witness *during* an ordinary exhibition of nitrous oxide are, in reality, dependent upon the absence of oxygen. That the anæsthesia is not due to asphyxia is probable from the fact that it is possible to secure absolute unconsciousness to pain, muscular relaxation, &c., from nitrous oxide mixed with such a proportion of oxygen that the development of obvious asphyxial phenomena is rendered physiologically impossible. Cyanosis, jerky and irregular breathing, deep stertor, and clonic movements of the extremities, are symptoms which, for many reasons, might well be dispensed with during the use of nitrous oxide. Whatever may be their significance, these phenomena are certainly suppressed when this gas is administered with about 10 or 15 per cent. of oxygen.

From what has been said in the preceding section of this chapter it is clear that, in a limited number of cases, it is possible, by the simple dilution of nitrous oxide with air, to lessen the tendency to lividity, tumultuous breathing, and jactitation, without interfering with the anæsthetic effects of the gas. As a routine procedure, however, the admixture is not to be recommended. There is one formidable objection to the use of air as an oxygenating agent, viz., that it contains such a large percentage of nitrogen. Although this latter gas, when given alone, will produce anæsthesia by excluding oxygen,[1] it cannot in any way contribute towards anæsthesia in the presence of that percentage of oxygen which is capable of preventing cyanosis and clonic muscular spasm. If we administer with nitrous oxide a percentage of air which will prevent lividity and the other symptoms referred to, we shall, in most cases, also prevent deep anæsthesia, owing to the small percentage of nitrous oxide which would be possible in such a mixture. For example: a mixture of 40 per cent. of air and 60 per cent. of nitrous oxide would contain about 8 per cent. of oxygen and about 32 per cent. of nitrogen; and although the 8 per cent. of oxygen would be sufficient to nearly or completely preserve the natural colour of the patient's face, and to suppress clonic muscular spasm, the 60 per cent. of nitrous oxide would probably be insufficient to produce tranquil anæsthesia. If, however, instead of using air for oxygenating purposes, we employ oxygen, we shall be ablo to replace the 32 per cent. of useless nitrogen by a corresponding quantity of useful nitrous oxide, and the proportion of the latter will now rise to 92 per cent. With such a large percentage of nitrous oxide, anæsthesia is almost certain to become established, and the percentage of oxygen remaining tho same as in the nitrous-oxide-and-air mixture, cyanosis and other evidences of diminished blood oxygenation will be prevented. These few considerations will act as a link to connect the preceding with the present section.

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[1] The reader is referred to pp. 268 and 269, where he will find details of several cases in which I administered nitrogen for tooth extractions.

I. *Nitrous Oxide and Oxygen administered under Increased Atmospheric Pressure* (*Paul Bert's Method*).

The late Paul Bert was the first to attempt to secure tranquil and perfect anæsthesia from nitrous oxide in the presence of oxygen. After a large number of experiments he came to the conclusion that, at ordinary atmospheric pressures, such a form of anæsthesia was unattainable. He regarded nitrous oxide as an agent which, at normal pressures, could only produce anæsthesia when administered by itself, that is, free from all other gases. The following remarks which he made in connection with this subject will express his views:[1]—

> "My experiments have demonstrated that, in an animal breathing pure nitrous oxide, when anæsthesia is established, 100 volumes of arterial blood contain 45 vols. of nitrous oxide. If, then, we introduce into the blood 45 vols. of nitrous oxide for every 100 vols. of blood, we shall obtain anæsthesia. Now, when pure nitrous oxide is contained in a bag under ordinary pressure this gas is at the tension of 100. But if the bag of gas is placed in an air-tight chamber, the pressure in which is raised to two atmospheres, the tension of the gas in the bag will be 200. And if this bag within the air-tight chamber, instead of containing 100 per cent. of nitrous oxide, viz., this gas in a state of perfect purity, contain only 50 per cent., the tension of this 50 per cent. of nitrous oxide will be equal to 100, that is to say, the quantity of nitrous oxide will be exactly that which is necessary to induce anæsthesia. The other 50 per cent. can therefore be occupied by another gas for sustaining life, viz. oxygen, and it will therefore be possible to carry out prolonged operations. I have chosen these figures to render the explanation of the method at which I have aimed more intelligible. But they must not be considered as indicating the proportions of the oxygen and nitrous oxide to be employed. The proportion of oxygen would be too high, in fact we know that air contains only 21 per cent. The problem therefore resolves itself into a very simple calculation. By mixing 85 parts of nitrous oxide with 15 parts of oxygen it is only necessary to raise the pressure to 89.5 cm. Supposing the barometrical pressure to be 76 cm., an extra pressure of only 13.5 cm. of mercury is required to induce anæsthesia. Under these conditions the animal operated upon soon falls asleep and into deep anæsthesia. The circulation and respiration are in no way influenced by the nitrous oxide, though the perceptive faculties are suspended, and if the quantity of the gaseous mixture inhaled by the animal is sufficient, it is possible to maintain the most absolute anæsthesia for several hours."

After a series of satisfactory experiments upon lower animals Bert put his theory to a practical test. He had constructed for

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[1] *Progrès Médicale*, No. 9, 1880. See also *Traité d'Anesthésie Chirurgicale*, by J. B. Rottenstein, Paris 1880, p. 303.

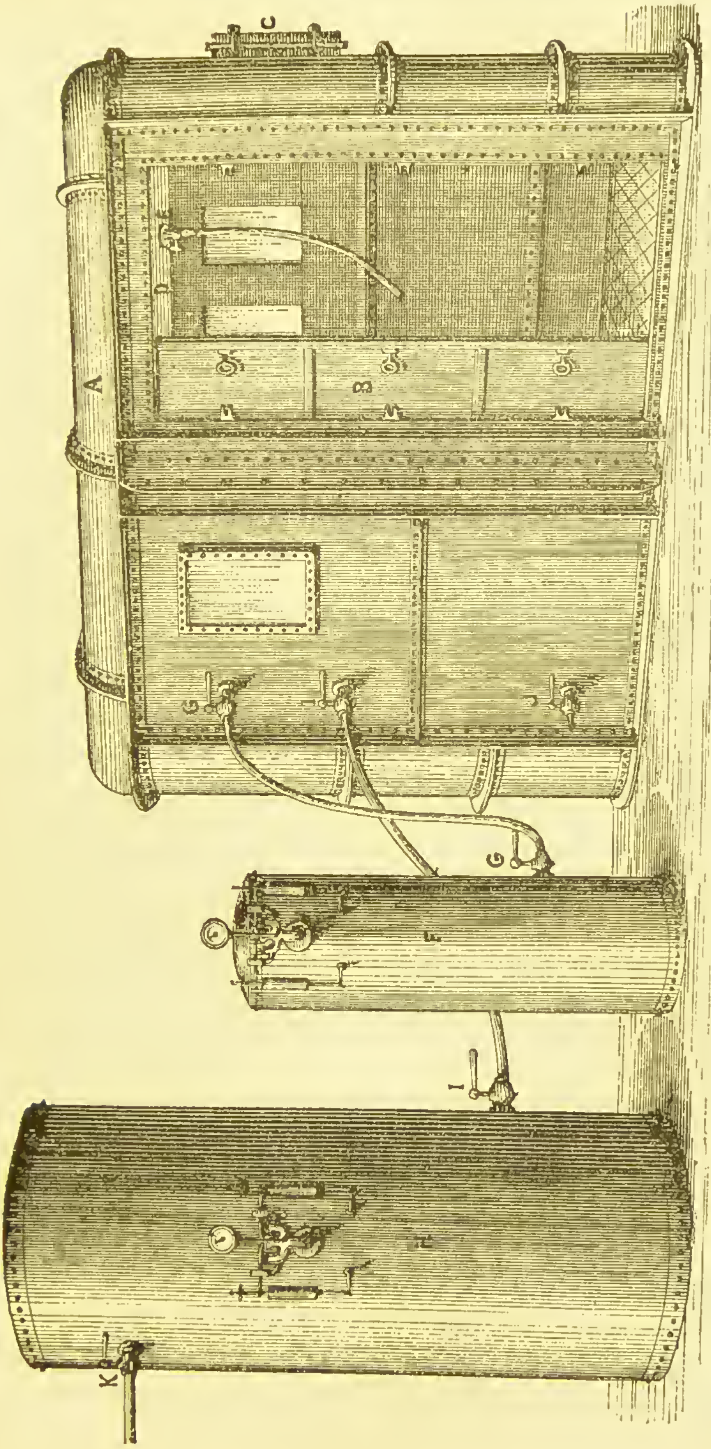

FIG. 22.—Air-tight Chamber for the Administration of Nitrous Oxide with Oxygen under an increased Atmospheric Pressure (Paul Bert's Method).

him by Dr. Fontaine a metal chamber in which the atmospheric pressure could be raised to the desired extent. The chamber was large enough to contain several persons. A mixture of 85 per cent. of nitrous oxide and 15 per cent. of oxygen was administered to a patient, and an extra pressure of 13.5 cm. (*i.e.* a total pressure of 89.5 cm.) was employed. The first operation during nitrous oxide and oxygen anæsthesia under pressure was performed by M. Léon Labbé on February 15, 1879. An in-growing toe-nail was painlessly removed during tranquil anæsthesia free from all traces of asphyxia. On March 20, 1879, M. Péan amputated a leg with equal success. Numerous other operations were performed. In the large majority of cases anæsthesia was of the most perfect type. There was no alteration of colour, the breathing was tranquil, and the pulse good and regular. In a few cases, however, excitement and nausea were noted.

The accompanying drawing shows a chamber which M. Claude Martin of Lyons has used successfully.[1] The following are its chief parts:—A. Air-tight metal chamber with windows. B. Sliding doors. C. Arrangement for introducing anything into chamber without lowering internal pressure. D. Canvas bag for holding the mixed gases. E. Tap through which the mixture passes to inhaling apparatus. F. Receiver containing mixed gases under greater pressure than that inside chamber. GG. Taps through which the mixed gases pass to the bag inside the chamber. H. Intermediate receiver for compressed air charged prior to the administration through the tap K. By using this intermediate receiver the compressed air which has been warmed by the action of the pumps is allowed to cool, and can be transmitted to the chamber when required through the taps II. J. Tap for lowering pressure in chamber, should occasion require. M. Martin found that he obtained best results when working with percentages and pressures somewhat different to those advocated by Paul Bert. He uses 88 per cent. of nitrous oxide with 12 per cent. of oxygen, and maintains an atmospheric pressure within the chamber of 110 cm. With the percentages and pressure recommended by Paul Bert he met with considerable excitement, which led him to modify the details of the method.

It is unnecessary to further describe Paul Bert's method. The apparatus necessary is, as will be gathered from the drawing, too complicated, too costly, and too cumbrous to allow of its being widely used. I am informed, too, on good authority, that the increased pressure within the chamber not infrequently produces considerable discomfort to those engaged in the operation. It is, in fact, questionable whether the advantages of this method of producing anæsthesia are of sufficient weight to overcome these objections.

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[1] M. Martin has very kindly given me permission to reproduce this drawing. The reader will find much interesting information in M. Martin's pamphlet, 'De l'Anesthésie par le Protoxyde d'Azote avec ou sans tension,' 1883.

II. *Nitrous Oxide and Oxygen administered at Ordinary Atmospheric Pressures.*

The results which were obtained by using Paul Bert's chamber were so satisfactory that attempts were soon made by many observers to secure a similar form of anæsthesia without employing an increased atmospheric pressure. As already mentioned Bert had been more or less unsuccessful in this direction. He regarded an increased atmospheric pressure as essential to tranquil anæsthesia. But experience has tended to shake our belief in the correctness of Bert's doctrines, seeing that a large number of successful administrations of nitrous oxide and oxygen at ordinary atmospheric pressures have now been recorded, and that in these administrations the symptoms displayed by the patients have been, in their main features, identical with those met with when using the air-tight chamber. It is true that, up to the present time, the *prolonged* maintenance of nitrous oxide anæsthesia in the presence of oxygen has been found to be impracticable except when employing an increased pressure. And it may also be true that excitable manifestations are less frequent and more under control when this increased pressure is brought into play. But the interesting fact remains that when nitrous oxide is administered with oxygen at normal pressure, by means of an apparatus which prevents the slightest admixture of atmospheric air, a very remarkable and satisfactory anæsthesia results in the vast majority of cases, and that such anæsthesia is eminently adapted for many brief operations, and for many types of patients.

Klikowitsch[1] is said to have been the first to successfully produce anæsthesia from nitrous oxide and oxygen in the absence of increased pressure. Zweifel subsequently met with similar success. But of all those who have worked in this direction Hillischer of Vienna has apparently had the largest experience. He has given the name of 'Schlafgas' to the mixture because of the sleep-like condition it produces. He has recorded 2901 administrations, the amount of oxygen employed varying from 10 to 15 per cent. The youngest patient was 3½, the oldest 82 years. Of the 2901 administrations eight were failures; but six of these failures were in the first 900 cases. Only two failures occurred in the subsequent 2000. In eleven cases minor operations (for epulis, removal of fragments of bone, &c.) were performed. In-some excitable cases as much as 85 litres (about 19 gals.) were necessary to secure anæsthesia. The smallest quantity required was 9 litres (2 gals.). The duration of available anæsthesia varied widely; in the majority of cases it was 40 to 70 seconds; the shortest time recorded was 15 seconds; and the longest 180 seconds. Twenty-three patients had morbus cordis. Several suffered from nervous affections. The mixture was administered to women immediately before and after confinement. No dangerous symptoms were noticed in any case. Ten per cent. of oxygen was usually employed to commence with, and the percentage then varied according to indications.

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[1] See an interesting pamphlet by Dr. Hillischer of Vienna, entitled 'Schlafgas.'

Dr. Hillischer's apparatus consists of a kind of cabinet which contains iron cylinders of nitrous oxide and of oxygen. Two large bags of Chinese silk are kept supplied from the cylinders by an assistant. Two short exit tubes pass from the bags to join a specially made inhaling tube. This latter is in reality a double tube, nitrous oxide passing along one half, and oxygen along the other. In cross section the double tube shows two semi-circular tubes, one for each gas. The exit tubes from the bags join the double inhaling tube at the wall of the cabinet; so that the double inhaling tube (looking like one tube) passes from the cabinet to the patient. At the free end of the inhaling tube there is a stop-cock containing valves, through which the mixed gases are breathed. The proportion of oxygen and of nitrous oxide respired is regulated by a revolving semi-circular plate guarding the orifices of the tubes, that is, it is interposed between these orifices and the stop-cock. The revolving plate is furnished with an indicator and dial to show the extent to which each semi-circular orifice is opened. When the nitrous oxide orifice is fully open the oxygen one is quite closed—100 per cent. of nitrous oxide. When the nitrous oxide orifice is half open the other is half open—50 per cent. of each gas. When the nitrous oxide tube is three-quarters open the oxygen tube is only a quarter open—25 per cent. of oxygen. A mouth-piece, to fit between the teeth, is used instead of the face-piece generally employed in this country.

That nitrous oxide and oxygen can be breathed for a long period without materially interfering with respiration or circulation is shown by a remarkable experiment of M. Claude Martin of Lyons, who administered to a dog a mixture of nitrous oxide with 15 per cent. of oxygen for three consecutive days (72 hours).[1]

M. Martin employed a chamber of the capacity of 250 litres, and capable of withstanding an internal pressure of 1.5 atmospheres. Dog put in at 5 P.M. 85 parts of nitrous oxide and 15 of oxygen introduced.

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[1] See a pamphlet entitled 'Sur l'anesthésie prolongée et continue par le mélange de protoxyde d'azote et d'oxygene sous pression (méthode Paul Bert),' by Claude Martin.

Pressure progressively raised to 110, 115, and 120 cm. At 6 P.M. dog well anæsthetised. 25 litres of the mixture supplied every hour. Potash solution used to absorb CO_2. After 12 hrs. respiration calm and remained so until end of experiment. After 72 hrs. dog removed. In 15 min. feet commenced to move and eyes opened. 35 min. later made efforts to stand, and trembled as if cold. After 35 min. he moved paws when pricked, and was able to walk and obey commands. He refused milk. Intelligence apparently unimpaired. At 7 A.M. next morning (14 hrs. after experiment) he was in good spirits, and ate well. The total amount of gas consumed was 2500 litres.

In 1886 I commenced a series of experimental administrations, wishing to put to the test the practicability of inducing and maintaining anæsthesia by nitrous oxide in the presence of oxygen at ordinary atmospheric pressures. I have elsewhere recorded the results obtained up to the month of April 1889.[1] Since that year I have continued to use mixtures of these gases, and at the present time I have records of 2000 administrations. In the very large proportion of cases it is possible to obtain a form of anæsthesia which, so far as my experience goes, is unequalled for brief operations. In order to achieve success, however, a great many details have to be carefully observed, and the symptoms of the patient narrowly watched, in order that the right proportion of oxygen in the particular case may be introduced with the anæsthetic gas.

Having referred to the views which have been advanced and the methods which have been adopted by others, I propose to conclude this section of the present chapter by giving the result of my own investigations on the subject.

A. APPARATUS AND METHODS OF ADMINISTRATION.

I should weary the reader were I to describe in detail the various forms of apparatus which I have tried for the administration of these gases.[2] I propose, therefore, to refer only to that which I now use, and which I find to answer very satisfactorily. In the earlier attempts at obtaining a workable apparatus it became obvious that no definite percentage of oxygen would answer for every case—some patients requiring comparatively small, others comparatively large proportions of oxygen. Hillischer's apparatus is portable enough, but it has one great drawback, viz., that the oxygen cannot be regulated with that nicety which is necessary in actual practice; in other words, a very small movement of its oxygen indicator means a considerable increment or decrement in the gas. This difficulty I have overcome in the apparatus here figured; for, as will be seen, the oxygen, on its way from the bag to the face-piece, is made to pass through

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[1] *Lancet*, April 27, 1889, p. 832.

[2] In a paper which I read at the Odontological Society (*Trans. Odont. Soc. Gt. Brit.*, June 1892) I described in detail the various forms of apparatus which I had tried.

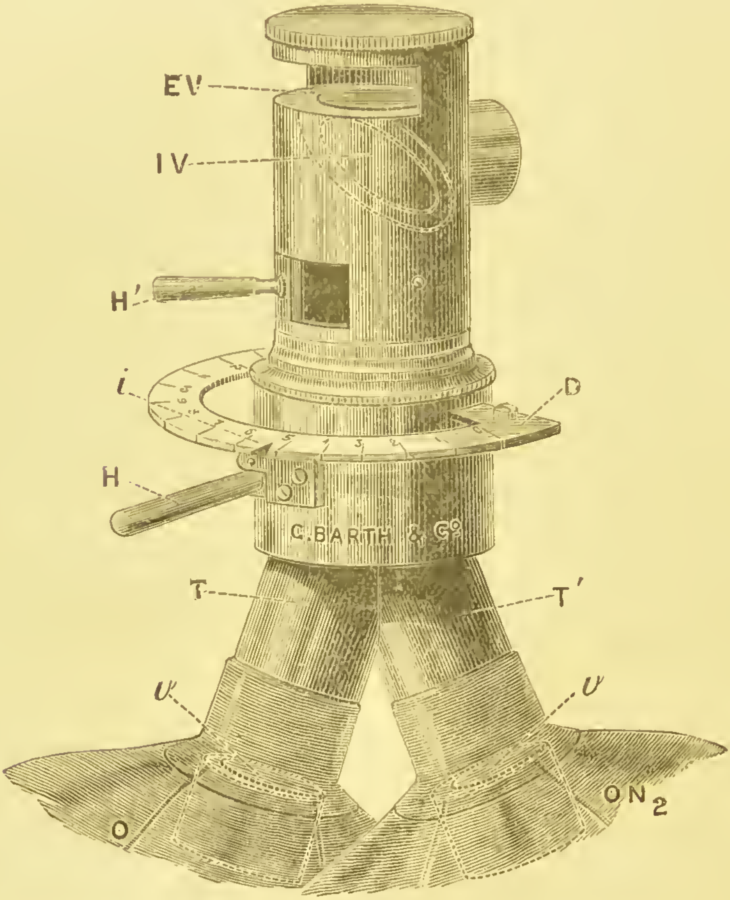

Fig. 23.—Stop-cock and Regulating Arrangement for the Administration of Oxygen with Nitrous Oxide.

minute circular holes, any number of which may be opened at a time.

Two india-rubber bags are employed: one for nitrous oxide, the other for oxygen (Fig. 23, ON_2 and O). These, which are fed from cylinders worked by the foot, are attached to two metal tubes T′ and T. Where the tubes join there is an arrangement by which oxygen may be added to the current of nitrous oxide to the desired extent. Above this regulating arrangement with its dial (D), indicating handle (H), and indicator (*i*), there is a two-way stop-cock, which allows, by the movement of its handle (H′), either of air or of the mixed gases being breathed. In order to permit the free escape of each expiration, two flap-valves, one an expiratory (EV), and one an inspiratory (IV), are provided. The tubes (T and T′) also possess flap-valves (*v* and *v*′) to prevent the contents of one bag passing over to the other. The oxygen tube T is considerably expanded above, so that the nitrous oxide tube may pass up through its middle. Oxygen thus travels along the circular channel left between the tubes, whilst nitrous oxide passes along the inner tube.

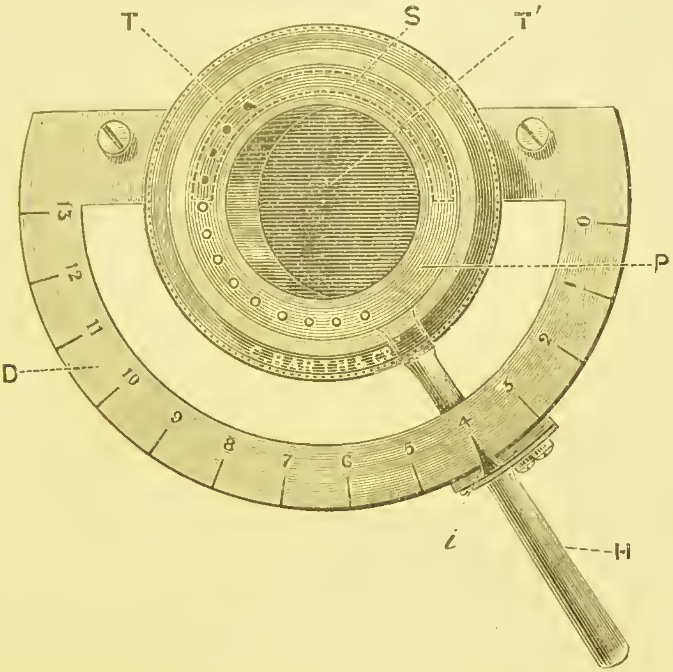

Fig. 24.—Dial-plate and Regulating Arrangement of Nitrous Oxide and Oxygen Apparatus, showing four holes open for the passage of oxygen.

Fig. 24 shows the central nitrous oxide tube (T′) and the expanded oxygen tube T. The space left between the nitrous oxide tube and the expanded oxygen tube is closed in by two circular plates, the upper of which (P) revolves by means of the handle (H) upon the lower, which is fixed. The upper plate has thirteen holes in it. The lower has a long slot (S) shown in dotted lines. When the handle (H) is turned, so that P revolves, one or more holes can be brought over the slot in the lower plate, and be thus rendered available for the passage of oxygen. In Fig. 24 the indicator points to '4' on the dial: *i.e.*, four holes are opened for oxygen and nine are closed. *By this plan a very small increment or decrement in oxygen is represented by a very considerable excursion of the indicator along the dial plate.* Notwithstanding that I have made a large number of experiments with the object of ascertaining what percentages of oxygen pass through these holes, I find it impossible to give any reliable averages, owing to the variations in pressure which must to some extent occur in the bags during the administration. All that I can say is that when both bags are kept partially distended, and one hole is open, a very small percentage (something between $3\frac{1}{2}$ and $6\frac{1}{2}$ per cent.) of oxygen will come through, and that each additional hole turned on represents something like an additional 1 per cent. or $1\frac{1}{2}$ per cent. of oxygen. In actual practice all we require is an apparatus which will allow of very small increments and decrements of oxygen. Should one bag ever be allowed to become fully distended the regulating apparatus will, of course, fail to work as such. If one bag be allowed to become more distended than the other the percentage of its gas will be higher than when the bags are of equal size. The apparatus here described allows (1) air, (2) nitrous oxide, or (3) nitrous oxide mixed with a proportion of oxygen, to be freely respired through valves at the will of the administrator. When ready for use it has the appearance represented in Fig. 25.

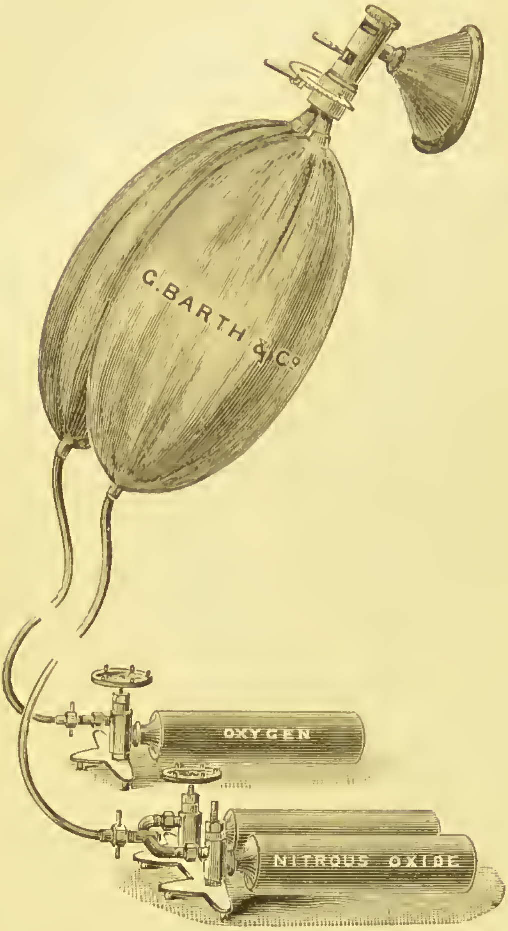

Fig. 25.—Nitrous Oxide and Oxygen Apparatus ready for use.

Before commencing **the administration** the anæsthetist should make sure that he has a sufficient supply of the two gases in the cylinders. In the next place, it is important not to charge the bags till immediately before the inhalation. The face-piece should be one which is capable of being applied to the face with the utmost accuracy, as a want of co-aptation which in the case of nitrous oxide alone would not be detrimental, would, in the case of the mixture, be likely to lead to partial or complete failure. The valves of the apparatus should work efficiently and freely. After passing a small quantity of the gases through the bags, in order to free them from all traces of air, the anæsthetist should turn off the two-way stop-cock, and place the oxygen indicator at '0.' Both bags should now be filled to about one-half with their respective gases, and the face-piece applied. Air will now be breathed freely through the apparatus, and the sound of the acting valves will prove that the face-piece fits well. The patient should be instructed to breathe freely and moderately deeply, 'in and out through the mouth.' This is important, for as he commences to breathe, so he will probably continue when the mixture is admitted. When the administrator sees and hears that breathing is free, and not till then, he should fix the oxygen indicator at '2,' and turn on the mixture at the two-way stop-cock. Nitrous oxide with a small percentage of oxygen will now be breathed. It is best to commence with a comparatively small percentage of oxygen, as we have to allow for that originally present in the lungs and blood. If we begin with, say 10 per cent., excitement will be more liable to arise than under other circumstances. The objection to giving pure nitrous oxide itself at the beginning, is that it is sometimes difficult to quickly neutralise the effects thus produced without going to the other extreme and administering too much oxygen. After two or three seconds the oxygen indicator may be turned to '3,' and in a few seconds more to '4.' In children, anæmic subjects, and debilitated persons, the indicator may be moved to '3' and '4' more quickly than in strongly-built or alcoholic individuals. During these manipulations the two bags must be kept as nearly as possible equal in size. It is rarely, if ever, necessary to replenish the oxygen bag during the administration, but the foot must be constantly kept on the nitrous oxide key. Considerable practice is necessary to keep both bags equal in size throughout. Should phonation, laughter, excited movement, or struggling assert itself, the administrator should withhold more oxygen for the present, or even give less of this gas, by turning back the indicator for a few breaths. In forty or fifty seconds from the commencement of the inhalation the indicator may usually be got as far as '5,' and in twenty seconds or so more may be allowed to point to '6,' '7,' or even '8.' Generally speaking, it is not advisable to give more oxygen than this. The administrator must judge from the symptoms of the patient the extent to which oxygen should be given. It is impossible to formulate any definite rules. Considerable practice is necessary, not only to get the face-piece to fit with extreme accuracy, and to keep the bags *half distended*, but to know when to give more, and when to give less oxygen. Whilst too much oxygen will be likely to induce laughter, excited movement, stamping, screaming,

&c., and whilst it is right, should such symptoms appear, to give less oxygen, the anæsthetist must be careful not to proceed too far in the opposite direction. In regulating the increase or decrease of oxygen we must reckon what the *future* effects of any procedure will be. For example, if some phonation occurs we should give somewhat less oxygen for a short period, but not necessarily till the phonation has ceased. We may usually turn back to the previous proportion of oxygen *before the symptoms of excitement have actually subsided*, knowing that they will subside in obedience to the lessened proportion of oxygen admitted several seconds previously. We have to pilot our patient along a narrow channel. On the one side we wish to avoid the clonic respiratory movements, &c., which prevent a free and lengthy intake of the anæsthetic; and on the other any inconvenient signs of incomplete anæsthesia. We must be sparing in our addition of oxygen in the case of those patients whose appearance suggests that they will be likely to require what we may call, for want of a better term, a strong dose of the anæsthetic. Patients who are easily affected by anæsthetics—such for example as children and debilitated persons of both sexes—may invariably be anæsthetised by nitrous oxide with a considerable percentage of oxygen; and as such patients are prone to 'jactitation' and a short anæsthesia, the mixture has great advantages over the ordinary gas.

B. EFFECTS PRODUCED BY THE ADMINISTRATION.

First Degree or Stage.—This is so similar to that already described as occurring under nitrous oxide *per se* that no further remarks are necessary. Some patients to whom I have given the mixed gases state that they have experienced less discomfort than with nitrous oxide alone; but this difference is, I think, very doubtful.[1]

Second Degree or Stage.—Consciousness is lost a trifle later than with nitrous oxide alone. When normal consciousness has been destroyed the period which elapses before true surgical anæsthesia occurs may, in certain types of subjects, be characterised by symptoms of excitement, which although they may and do sometimes appear with nitrous oxide alone, are certainly less common with the last-named agent when unmixed with oxygen. Alcoholic subjects, and those whose nervous systems have become undermined by excessive work, worry, &c., may move their arms or legs, laugh, or gesticulate during this stage. Such symptoms are, however, quite exceptional, and always point to too much oxygen or to the admission of air. Excitement occurring during the administration may usually be at once stopped by increasing the percentage of nitrous oxide. In order to secure a tranquil anæsthesia the patient should invariably be kept as quiet as possible. During the first minute or so of the inhalation slight stimuli may evoke rhythmical movements of the legs or arms, shouting, &c.—symptoms which would have been avoided had the patient not been disturbed. The chance of excitement arising is greatly lessened when, following the instructions of the administrator, the patient breathes the mixed gases freely and deeply; for by so doing he not only more rapidly passes over that stage in which excitement is prone to manifest itself, but all unpleasant sensations incidental to holding the breath—sensations which may readily initiate distressing dreams—will be prevented. The respiration during this stage not infrequently becomes very deep and rapid, and then abruptly calm or even imperceptible. There is no cause for anxiety in this rapid respiration; it always co-exists with a good regular pulse and florid colour, and gradually gives place to tranquil, unembarrassed, and distantly-snoring breathing, as deep anæsthesia approaches.

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[1] I myself have inhaled nitrous oxide with oxygen on more than one occasion, and the initial sensations are very similar to those of nitrous oxide alone.

Third Degree or Stage.—When the typical anæsthesia of nitrous oxide and oxygen has become established, the patient's condition will be suggestive of natural sleep.

The **respiration** is usually remarkably calm and perfectly regular during this stage. A barely audible inspiratory roughness or snoring is not uncommon. The loud 'stertor,' as well as the peculiar and characteristic guttural sound of ordinary nitrous oxide administration are never met with, unless indeed the percentage of oxygen should be so small as to be useless for oxygenating purposes. Respiration is rhythmically performed throughout; and the tumultuous thoracic and abdominal movements, sometimes witnessed when nitrous oxide is administered free from all oxygen, are strikingly absent. Owing to there being less venous engorgement, and hence less swelling of all parts within the upper air-tract, when oxygen is used with nitrous oxide than when the latter is given in the ordinary manner, patients with enlarged tonsils may be anæsthetised without any tendency to obstructed breathing.

The **colour of the face and lips** remains unaltered, or even becomes more florid. The duskiness and lividity so common under nitrous oxide are, generally speaking, entirely absent. As will subsequently be pointed out, it is sometimes necessary during the administration of the mixture, either to bring down the proportion of oxygen below 10 per cent., or to give pure nitrous oxide for a short period; and, under such circumstances, a variable degree of duskiness would of course ensue. It is remarkable, however, that when a patient's colour has become florid from the inhalation of nitrous oxide and oxygen, the change to pure nitrous oxide takes a considerable time to cause any noticeable lividity, and signs of anæsthesia are wont to assert themselves before any marked duskiness becomes manifest. Anæmic patients, and those who are pale from fright, often display a rosy tint as the administration proceeds.

The **circulation** is vigorously maintained during deep anæsthesia. The pulse is generally fuller and slower than that observed when nitrous oxide, free from air or oxygen, is freely administered. I have administered nitrous oxide with oxygen to patients whose circulatory functions were at the time of inhalation seriously disorganised, and can testify to the very satisfactory manner in which the mixed gases have been taken. I have given the mixture to a patient in a half-fainting condition, sitting vertically in a chair, and have found an almost imperceptible pulse to become perceptible and of fair volume during the inhalation.

Clonic **muscular movements** are usually conspicuous by their absence; and the so-called 'jactitation' of nitrous oxide is, with the rarest exception, never witnessed. A minor degree of tonic spasm in the muscles of the neck, back, and extremities, is often manifested, more especially as the immediate reflex result of the operation. Opisthotonus very rarely occurs. As a general rule, the whole of the muscular system becomes relaxed, and if, when anæsthesia is established, the patient's arm be lifted by the administrator, it will fall flaccid to the side. The absence of 'jactitation' in children is a great boon to the operator. It is highly probable that by the use of oxygen with nitrous oxide the chance of micturition during anæsthesia is very greatly reduced. I have only met with it once in my 2000 cases.

The condition of the **eyelids, globes, and pupils** deserves special notice. The eyes usually remain closed throughout the administration. During the first 45 or 60 seconds any attempt to raise the upper lid will cause a reflex tightening of the orbicularis. This spasm, however, gradually passes away as the inhalation proceeds, and at the end of about 75 or 90 seconds the upper lid may usually be raised without resistance. The eyeballs will now be found to be fixed, and in many cases turned to the right or left. In some instances there may be observed slight oscillatory movements of the globes; not as rapid as those of ordinary nystagmus, but not so slow as those which would indicate conscious observation on the part of the patient. The pupils are variable. As a general rule they are of moderate size. Wide dilatation, such as that usually met with under nitrous oxide free from oxygen, is distinctly rare. I have on many occasions witnessed contraction and dilatation of the pupil in almost immediate response to a greater or less percentage of oxygen. The pupils may of course reflexly dilate during the extraction of a tooth, even though the patient is absolutely unconscious and free from all pain. The conjunctival reflex is, in the vast majority of cases, quite absent, though the cornea may be sensitive to touch.

Reflex **phonation**, as for example during tooth extraction, is, as with nitrous oxide itself, sometimes met with; but, as the anæsthesia when oxygen is used is deeper than when nitrous oxide alone is employed, such phonation, other things being equal, is less likely to arise. Of 153 dental cases I noted it, more or less, in 29.

Anæsthesia is known to be present by one or all of the following signs:—

1. The conjunctival reflex is lost.
2. The breathing is regular and tranquil, or is softly snoring in character (like the breathing of good chloroform anæsthesia).
3. The arms are flaccid.
4. The eye-balls are fixed or present slight oscillatory movements.

Sometimes the conjunctiva is sensitive, in which case the breathing or muscular flaccidity must be relied upon; but, speaking generally, the administration should be continued till the conjunctival reflex is lost. Should it be found advisable, as often happens, to give a smaller percentage of oxygen than usual, or should the patient be extremely susceptible to the anæsthetic gas, *slight* irregular muscular twitchings (mild 'jactitation') may arise, and if the face-piece be then removed a good anæsthesia will result. In some cases the muscular system, instead of being relaxed, is rigid at the acme of anæsthesia, but such cases are exceptional. Alcoholic patients appear to be particularly liable to this rigidity.

C. TIME TAKEN TO PRODUCE DEEP ANÆSTHESIA.

The period of inhalation requisite to secure deep anæsthesia varies considerably in different cases; some patients being, for reasons already given, far more quickly and deeply affected by nitrous oxide than others. Of sixty-seven carefully (métronome) timed dental administrations with the apparatus above described, I found the average period of inhalation to be 110·5 secs., a figure which represents the average period of inhalation found necessary to provide the operator with a subsequent anæsthesia of sufficient duration for the performance of an average dental operation. In dental anæsthetisation the administration is usually carried on for some seconds after anæsthesia has become established. In other minor surgical cases the operation might be begun immediately signs of anæsthesia occur, *i.e.*, after about 60 or 70 seconds' inhalation. Should the percentage of oxygen be accidentally or intentionally smaller than that usually given, stertor may be induced and the period of inhalation be thus curtailed. I have administered nitrous oxide with oxygen for several minor operations, such as the incision of a whitlow, tenotomy, the division of deep plantar fascia, &c. I find the plan answers very well indeed in most cases, but it is somewhat difficult in every case to regulate the proportion of oxygen which should be given. Too much will interfere with anæsthesia; too little will render continuous inhalation impossible. I have kept up a good form of anæsthesia for 4 to 5 min., admitting a breath of air occasionally, and regulating the percentage of oxygen by the kind of patient undergoing the operation. So far, however, as I am able to judge at present, the mixture answers best when the period of inhalation is of brief duration (1 to 3 min.).

D. THE AVAILABLE PERIOD OF ANÆSTHESIA AFTER THE INHALATION.

The available period of anæsthesia after the withdrawal of the mixture becomes a matter of importance in those operations, such as the extraction of teeth, which render continuous administration impracticable. In sixty-nine carefully (métronome) timed dental administrations the average available period of anæsthesia was 44 seconds. It is right, however, to point out that great variation occurs in the duration of this period. The longest anæsthesia was 90 seconds; the shortest 21 seconds. Within certain limits, the longer the administration the longer will be the subsequent anæsthesia. This consideration doubtless explains the fact that the resulting anæsthesia from a single dose of nitrous oxide (the average inhalation period of which is about 51 seconds) is considerably shorter than that obtainable from nitrous oxide in the presence of oxygen. The following figures show this very clearly :—

Anæsthetic Employed.	Average Period of Inhalation for Dental Operations.	Average Period of Resulting Anæsthesia.
Nitrous oxide *per se* . .	about 51 secs.	about 30 secs.
Nitrous oxide mixed with a percentage of oxygen sufficient to prevent all asphyxial phenomena . . .	about 110 secs.	about 44 secs.

E. DANGERS CONNECTED WITH THE ADMINISTRATION.

There is no form of anæsthesia at present known which is so devoid of danger as that which results from nitrous oxide when administered with a sufficient percentage of oxygen to prevent all asphyxial complications. In 2000 cases, of which I have kept careful notes, I have never detected the slightest sign of respiratory embarrassment or cardiac depression. Owing to the fact that little or no strain is thrown upon the circulation, it is in the highest degree probable that persons with feeble and dilated hearts would be anæsthetised by nitrous oxide and oxygen, without that slight risk which obtains when the former gas is administered alone. Moreover, those patients who by reason of senile or other changes in the thoracic parietes, pleura, or lungs, might evince symptoms of embarrassed breathing at the acme of ordinary nitrous oxide anæsthesia, would certainly be less likely to do so in the presence of oxygen. Seeing, however, that nitrous oxide when administered free from oxygen is a practically safe anæsthetic in moderately healthy subjects, it is unnecessary here to emphasise the advantages of this mixture. One may perhaps add, in conclusion, that there is not quite the same risk of foreign bodies entering the larynx and trachea during dental operations under the influence of nitrous oxide and oxygen, as there is when using nitrous oxide alone (see p. 300). This is owing to the fact that the jerky movements and opisthotonic condition, so often met with when nitrous oxide is freely administered without oxygen, somewhat increase the chances of this accident.

F. AFTER-EFFECTS.

The recovery from the effects of this mixture is usually very satisfactory, though not quite as speedy as from nitrous oxide alone. We can hardly expect this, indeed, to be so, seeing that the inhalation is invariably longer when nitrous oxide is given with oxygen. There is an absence of that abrupt return to consciousness which is met with in the case of unmixed nitrous oxide. Patients are a little more dazed and are not able to leave the chair quite as quickly as in the case of nitrous oxide alone. The difference, however, is slight; and when the inhalation has been short there is practically no difference to be detected. It is only when an inhalation of two to three minutes, or longer, has been conducted, that the more tardy recovery manifests itself. The longer the inhalation, the greater will be the tendency to these after-effects. Nausea, or actual vomiting, although very rare, are more common than after nitrous oxide alone—a fact which must not be entirely lost sight of. (See p. 68.)

G. ILLUSTRATIVE CASES.

In the following table are given four illustrative cases. The times were taken by a métronome, and an assistant recorded the symptoms of the patients. The table shows the effect of more and less oxygen, the intervals at which the gas was admitted, and many other points.

Illust. Case, No. 1.

A typical case.

Sex and age.—M. 18.

Description.—Fairly nourished; good colour. A postman.

A.—*Period of Inhalation.*

Secs.	Oxygen Indicator at	*Symptoms.*
0	2	
18	3	Six breaths taken.
33	4	
39	4	Deep respiration.
51	5	
72	5	Quieter breathing.
78	6	
90	6	No conjunctival reflex.
99	6	Pupils 3½ mm. in diameter.
108	6	Inhalation stopped.

B.—*Available Anæsthesia after Removal of Face-piece.*

Secs.	*Symptoms.*
3	Good colour.
9	No movement or phonation.
21	Opposite side of mouth being operated upon.
30	Operation over.
42	Anæsthesia at an end.

Teeth or stumps extracted.—4.
General result.—Typical.
Remarks.—No pain. No phonation or movement; no stertor or muscular twitching; good recovery; dreamt he was at his work.

Illust. Case, No. 2.

A typical case except for slight duskiness. See remarks.

Sex and Age.—F. 33.

Description.—Spare; sallow.

A.—*Period of Inhalation.*

Secs.	Oxygen Indicator at	*Symptoms.*
0	2	
12	3	
24	4	
39	5	
51	6	
57	6	Twitching of eyelids.
66	6	Conjunctival reflex not abolished.
72	7	
78	7	Restless movement in chair.
81	5	
84	3	
87	2	
93	3	Movement ceased.
96	5	
108	5	Slight conjunctival reflex.
120	5	No conjunctival reflex.
123	5	Breathing quicker and more audible.
126	5	Inhalation stopped.

B.—*Available Anæsthesia after Removal of Face-piece.*

Secs.	*Symptoms.*
3	Distinctly dusky.
9	Very slight phonation.
12	Normal colour returned.
24	Some movement of legs.
30	Anæsthesia at an end.

Teeth or stumps extracted.—4.
General result.—Good but not typical.
Remarks.—Restless movements probably due to too much oxygen at 72 secs. Movements quite controlled by less oxygen (more N_2O); but some duskiness at end due to this diminished quantity. Otherwise typical. No 'stertor' or 'jactitation.'

Illust. Case, No. 3.

Long inhalation and long anæsthesia after.

Sex and Age.—F. 33.

Description.—Fairly well-nourished; fair complexion.

A.—*Period of Inhalation.*

Secs.	Oxygen Indicator at	*Symptoms.*
0	2	
18	3	
30	4	
36	5	Quicker breathing.
54	6	
60	6	Quieter breathing.
72	6	Soft snoring.
84	6	Ditto.
96	7	Distinct conjunctival reflex.
108	7	Snoring passing off. Slight rigidity of neck.
132	7	Tendency to turn head to left. Conjunctival reflex still present.
150	8	Very slight snoring.
171	8	Conjunctival reflex slight.
177	8	Some phonation.
180	8	Breathing quicker and more audible.
186	8	Inhalation stopped.

B.—*Available Anæsthesia after Removal of Face-piece.*

Secs.	*Symptoms.*
9	Some phonation.
18	Phonation ceased, operation proceeding.
27	Slight rigidity, good colour.
48	Movement of hand towards head.
66	Extraction finished.

Teeth or stumps extracted.—4.

General result.—Very good, barely typical.

Remarks.—She slightly felt the last stump. Probably deduct 6 secs. from 66 above mentioned. Instance of long administration and long anæsthesia. A good deal of oxygen given.

Illust. Case, No. 4.

Too much oxygen given intentionally for purposes of demonstration. Excitement thus produced easily controlled.

Sex and Age.—F. 37.

Description.—Healthy appearance. (Pulse 120 before prop inserted.)

A.—*Period of Inhalation.*

Secs.	Oxygen Indicator at	*Symptoms.*
0	3	
6	3	Pulse 132.
18	4	
21	4	Pulse 144.
33	4	Average breathing.
36	4	Tranquil breathing.
42	5	
51	5	Very calm breathing.
54	6	
66	5	Slight evidences of approaching excitement.
69	4	
72	4	Some phonation.
78	3	Restless movement in chair, with tendency to slip forward.
81	3	Pulse 120.
84	4	
93	5	Quite quiet.
102	5	Inhalation stopped.

B.—*Available Anæsthesia after Removal of Face-piece.*

Secs.	*Symptoms.*
3	Colour a trifle dusky.
15	No phonation.
21	Conjunctiva insensitive.
36	Anæsthesia at an end.

Teeth or stumps extracted.—1.

General result.—Very good, barely typical.

Remarks.—Started with oxygen indicator at '3' instead of '2,' and turned it to '4' in 18 seconds.

CHAPTER II.

ETHER.

A. APPARATUS AND METHODS OF ADMINISTRATION.

We have now to consider the chief methods for the administration of ether *per se*, *i.e.*, independently of any other anæsthetic. As will subsequently be pointed out, ether may, with much advantage, be preceded by nitrous oxide (Chap. III. p. 175), or a small quantity of the A. C. E. mixture (Chap. VI. p. 254). But if these agents be not at hand, or if simplicity in procedure be desired, ether must be given throughout.

Before proceeding further it is necessary that the reader should possess a very clear idea of the differences between what may be termed—

I. Open methods; and

II. Close methods of administration.

In 'open' etherisation a plentiful supply of air is allowed with the anæsthetic, or at all events there is no provision in the inhaler for permitting to-and-fro breathing, or for limiting the supply of air. In 'close' methods of administration a bag-inhaler is employed, so that to-and-fro breathing is permitted, and the supply of air during the inhalation of ether-vapour is intentionally restricted. The phenomena which attend and follow the process of etherisation, as well as the amount of ether used to secure tranquil anæsthesia will be found to be, to a considerable degree, dependent upon whether the ether is administered by means of an open or a close inhaler.

I. *Open Methods of Administration.*

When ether was first introduced it was administered by means of a towel folded and pinned into the shape of a cone, and at the apex of this cone a sponge was placed for the reception of the ether. The sponge was usually wrung out in warm water before use. The anæsthetic was poured upon the sponge in small quantities at a time, and the cone applied, more or less continuously, to the face of the patient. Cone-shaped inhalers of felt, with an outer covering of mackintosh to prevent undue evaporation, were then devised, and are still used by some. These cones are also furnished with sponges, and are slightly open at their apices, so that air may gain admission. They have been used for a great many years both in England and in America, and certainly have the merit of simplicity. One of the best of the open ether inhalers is shown in Fig. 26. It is known as Rendle's mask. The inhaler is made of leather, and has numerous holes at one end. A long large-mouthed bag of domett or flannel is used as a lining, its mouth being brought back over the mouth of the leather inhaler, so that when the latter is applied to the patient's face a soft surface of domett or flannel comes against the cheeks. A sponge is placed at the bottom of the inhaler, and ether is poured upon it as in the cone-inhalers. In America the apparatus shown in Fig. 27, and known as Allis's ether inhaler,[1] is largely used.

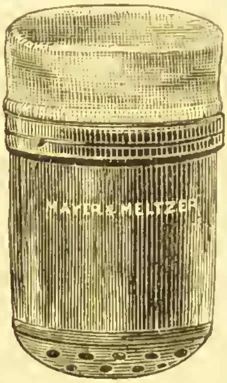

FIG. 26.—Rendle's Mask.

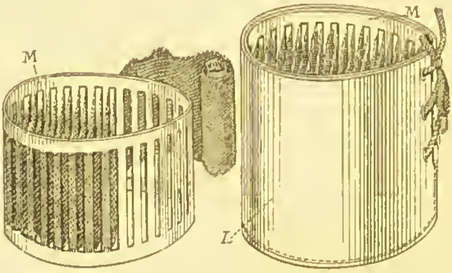

FIG. 27.—Allis's Ether Inhaler.

It consists of a cylindrical metal frame (M) with long spaces punched out of its circumference, so that a bandage may be threaded backwards and forwards across the open cylinder, as shown in the figure. The metal frame is enclosed by a leather case (L) which is longer than the metal frame, so that the part of the leather case which is unoccupied by the frame may fit the face of the patient. Ether is dropped or poured upon the bandage as required. By this arrangement the breath passes over a large surface of bandage moistened with ether. Allis's inhaler has not been used, at all events to any great extent, in this country. Numerous other open ether inhalers have been devised, but space forbids me referring to them here.

The **administration of ether by means of an open inhaler** is such a simple proceeding that details are hardly necessary. In adults a drachm or two should be first placed within the inhaler, and the latter held that distance from the face which is found to be necessary in order to avoid cough or holding of the breath. Too strong a vapour will cause instant closure of the larynx and a sense of suffocation. Allis's inhaler certainly has the advantage of allowing of a more gradual increase in the strength of ether than is possible in cone-inhalers, which have to be removed from time to time in order to be re-charged. The administrator must steer between too sparing and too liberal a use of the anæsthetic. If he administers a very small quantity at a time the patient will take a long period to become anæsthetised, and should excitement occur it will take longer to disappear than when larger doses of the anæsthetic are used. Should the administrator commence with too pungent a vapour the patient will experience the most horrible sense of suffocation, the breath will be held for prolonged periods, and violent struggling will probably arise. It is therefore best to start with a vapour diluted with air, according to the indications present, and when the patient is getting dazed and losing consciousness to gradually but progressively increase the strength of vapour. The effect of the ether upon the larynx must be watched, and the quantity regulated accordingly. Respiratory rhythm is always interfered with, more or less, by swallowing movements, temporary closure of the larynx, &c. By degrees, however, the larynx gets accustomed to the vapour; it becomes less sensitive, and respiration hence grows more regular. When once unconsciousness has become established any tendency to excitement or struggling must be met by a more continuous application of the anæsthetic. There is not that danger in pushing ether at this stage that we know to exist with chloroform. Should the sponge of an open inhaler become frozen by the evaporation of the ether, it must be removed and immersed in warm water before being again used, otherwise it may be impossible to obtain a sufficient quantity of ether from the inhaler. When administering ether by the open method large quantities of the anæsthetic are needed to secure and maintain anæsthesia, especially in alcoholic and vigorous subjects. It would, for example, be necessary to have at hand at least a pint of ether in order to successfully anæsthetise an alcoholic and stalwart patient for an operation of considerable duration. A very large proportion of the anæsthetic is, of course, wasted; and the room may become almost unbearable from the presence of so much ether vapour. Excitement, struggling, &c., are far more common than when a close inhaler is employed. The risk of catarrhal, bronchial, and pulmonary affections is probably greater in administering ether by the open than by the close method.

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[1] *Philadelphia Medical Times*, No. 162. Fig. 27 is copied, by Dr. Turnbull's kind permission, from his work on Anæsthetics.

But although open etherisation has many objections as a routine procedure, it has advantages in certain cases. There is nothing simpler than to pour ether from time to time into a cone; and when a totally inexperienced practitioner is called upon to anæsthetise a patient with ether, he will be less likely to do harm by administering ether as above described than if he employs a close inhaler. In very exhausted and cachectic patients, in those suffering from advanced morbus cordis and orthopnœa, and in many cases in which an operation for empyema is required, open etherisation will be found to be of advantage. Moreover, when anæsthetising infants with ether this plan should be adopted. (See Illust. Cases, Nos. 8, 9, and 10, p. 174.)

II. *Close Methods of Administration*, i.e., *with Bag-Inhalers.*

It is doubtful who first recognised the advantages of limiting the access of fresh air during the inhalation of ether vapour. The late Professor J. Morgan of Dublin appears to have been the first writer in this country who drew attention to these advantages,[1] but he refers to Professor Porta of Pavia[2] and to Dr. Smith of New York, both of whom had, prior to his (Dr. Morgan's) lectures, administered ether from a bladder or bag. Dr. Morgan's ether inhaler (described by him in 1872) consisted of a box or reservoir for the ether, and a flexible tube and mouthpiece through which the patient breathed the vapour. The box was furnished with an india-rubber diaphragm capable of expanding and contracting as the patient breathed.[3] In July 1876, Clover described[4] 'An apparatus for administering nitrous oxide gas and ether singly or combined;' and at the time he wrote he had used this apparatus successfully in 2300 cases. The ether vapour, supplied from a reservoir, was breathed backwards and forwards from a bag attached to the face-piece, fresh air being admitted from time to time. In January 1877, Clover described[5] his 'Portable Regulating Ether Inhaler' (Fig. 28, p. 139). In February of the same year Dr. Ormsby of Dublin introduced[6] his apparatus (Fig. 34, p. 148) to the notice of the profession. Since this time no other ether inhalers worthy of mention have been invented. Whilst Clover's ether inhaler has certain advantages over Ormsby's, the latter apparatus very favourably compares with the former in many respects. I shall therefore fully describe these two inhalers, the method of using each, and the advantages of the one over the other.

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[1] See an interesting article by Professor J. Morgan, entitled 'Ether *versus* Chloroform. On the uses of ether as an anæsthetic in surgical operations, as a safer and more efficient agent than chloroform in producing the avoidance of pain. With a description of an inhaler, and the mode of administration' (*Med. Press and Circular*, July 31, 1872).

[2] Asshurst, 'Principles and Practice of Surgery,' p. 77.

[3] *Med. Press and Circular*, August 28, 1872, p. 165.

[4] *Brit. Med. Journ.*, July 15, 1876, p. 74. This apparatus will be described when discussing the administration of nitrous oxide with ether in Chapter III. of this Part.

[5] *Brit. Med Journ.*, January 20, 1877, p. 69.

[6] *Lancet*, Feb. 10, 1877, p. 218; also June 9, 1877, p. 86.

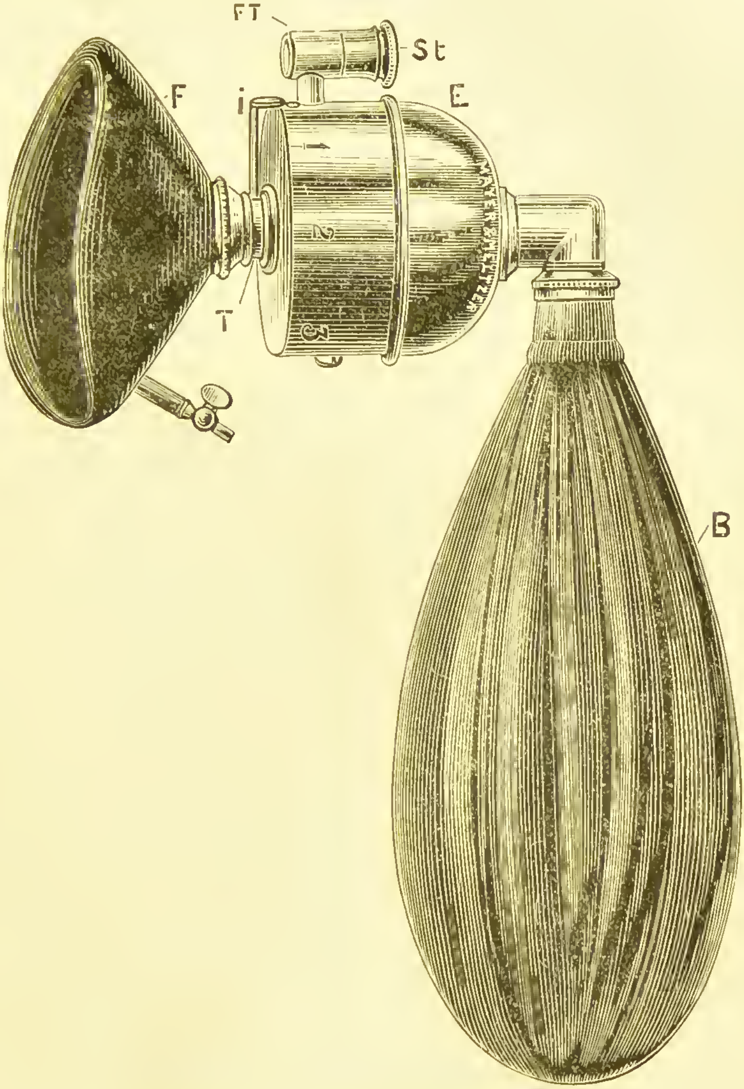

FIG. 28.—Clover's Portable Regulating Ether Inhaler.

Clover's Portable Regulating Ether Inhaler.

This most ingenious and useful apparatus is represented in Figs. 28, 30, and 31. When ready for use it has the appearance represented in Fig. 28. F is the face-piece ; E is the ether reservoir through which the air-current passes ; and B is an india-rubber bag. When the face-piece fits the face accurately the patient breathes backwards and forwards into the bag. There are no valves, and there is no provision for the ingress of fresh air. The face-piece tightly plugs on to a tube T, which fits into one end of a shaft passing through the ether reservoir. The mount of the bag B fits into the other end of this shaft. By revolving the ether reservoir on the tube T the current is made to pass to any desired extent over ether. The apparatus is charged with ether at the funnel-shaped tube FT, the stopper of which is removed for the purpose. A little measure is usually supplied with the inhaler, and is used for filling it with ether. The face-piece and bag hardly need further description; but the ether reservoir must be carefully considered, in order that the working of the inhaler may be understood.

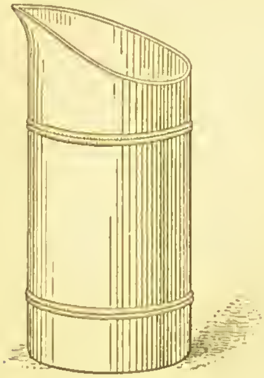

FIG. 29.—Measure for filling Clover's Ether Inhaler. (Half size.)

In Figs. 30 and 31 the ether reservoir E and the tube T are shown in section. E consists essentially of a metal sphere tunnelled by the shaft S, into which T fits. The sphere is the reservoir for the ether.

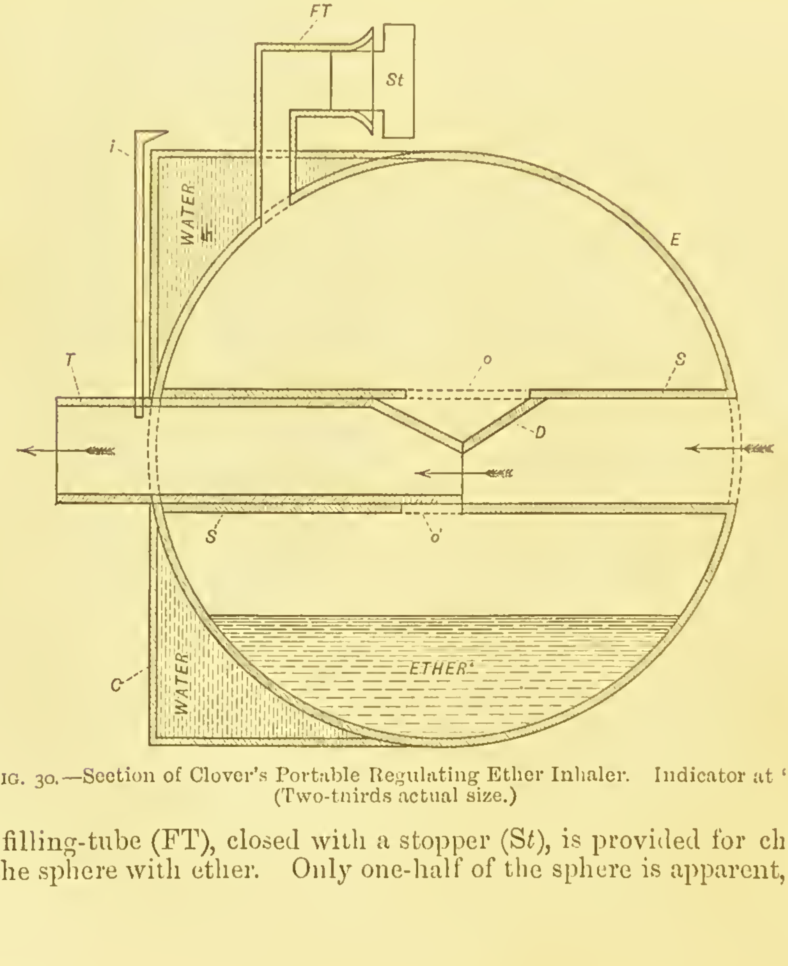

FIG. 30.—Section of Clover's Portable Regulating Ether Inhaler. Indicator at 'o.' (Two-thirds actual size.)

The filling-tube (FT), closed with a stopper (S*t*), is provided for charging the sphere with ether. Only one-half of the sphere is apparent, the other being covered in by a cylindrical cap or cover (C). The space which results is nearly filled with water by the makers of the instrument. This water-chamber prevents the apparatus from becoming too cold. When the temperature of the room is low, it is a good plan to immerse the inhaler in warm water for a few moments before use, by which plan the water in the water-chamber takes up and retains heat for a sufficient time to ensure a proper evaporation of ether in the adjacent sphere. About half way along the shaft there are four large openings, two (O) on the upper wall of the shaft and two (O′) on the lower. These allow of communication between the interior of the shaft on the one hand and the ether reservoir on the other. These openings are so large that the shaft S almost loses its continuity where they occur. Projecting from the wall of the shaft there is a half diaphragm D, which closes up one-half of the calibre of the shaft, leaving the other half free. This half diaphragm is not fixed at right angles to the long axis of the shaft, but is sloped as shown. The tube T, upon which the face-piece plugs, passes into the shaft S. It has a whistle-shaped end which fits up against the half diaphragm D. It also carries a long rod or indicator (*i*), which points to figures on the circumference of the ether reservoir (Fig. 28). When the face-piece and tube T are fixed, as in actual ad-

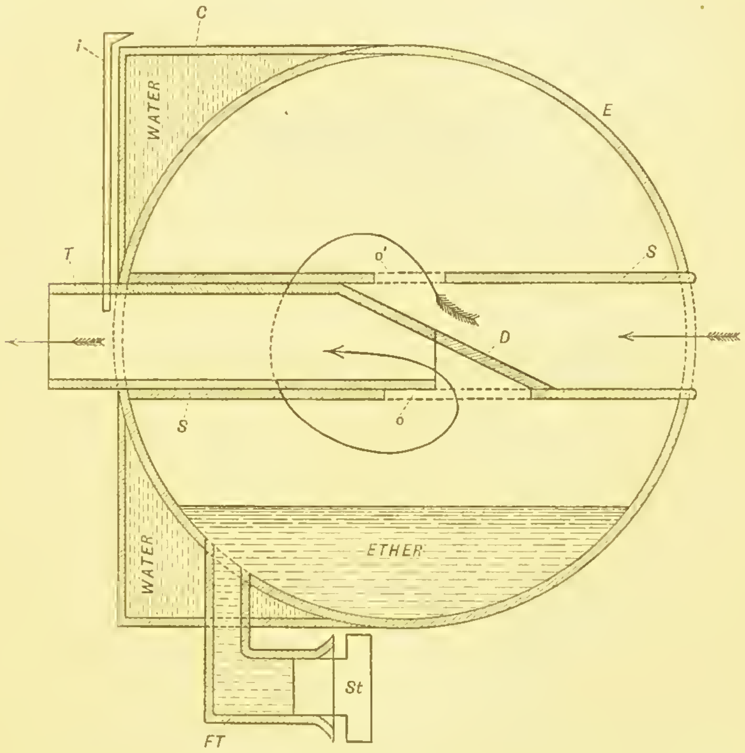

FIG. 31.—Section of Clover's Portable Regulating Ether Inhaler. Indicator at 'F.' (Two-thirds actual size.)

ministration, the ether reservoir rotates easily upon T, and so the figures on the circumference travel one after the other past the indicator (*i*). Should the ether reservoir be fixed, the face-piece, tube, and indicator would, of course, revolve. If the indicator points to '0,' and the face-piece and bag are attached to the ether reservoir, an inspiration on the part of the patient will take the course shown in Fig. 30. It will pass straight through the shaft without in any way entering the chamber containing the ether. The openings (O and O′) in the shaft are rendered unavailable, the upper ones (O) by reason of the half diaphragm D, and the lower ones (O′) by the whistle-shaped end of the tube T. When the ether reservoir is rotated, however, so that the filling tube passes

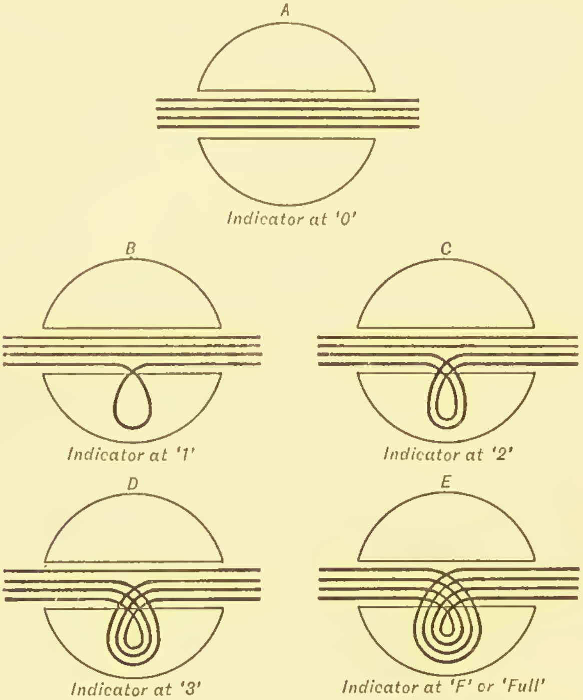

FIG. 32.—Diagram showing the extent to which the air-current passes over ether in Clover's Portable Inhaler when the indicator points to '0,' '1,' '2,' '3,' and 'F.' The whole current is diagramatically represented by four lines.

away from, and eventually gets opposite to the indicator, which now points to 'F' on the circumference of the ether reservoir, the course of an inspiration on the part of the patient will be very different. It will now enter the opening O′, and having passed over the ether (see long arrow), will escape at the opening O into the tube T, and so pass to the patient. The whole of the current will thus become deflected and made to pass over the ether. An expiration on the part of the patient would, of course, travel backwards to the bag by exactly the same route as the inspiration came. The two sectional drawings show the course of an inspiration with the indicator at '0' and 'F' respectively. The degree to which the current is made to pass over the ether will depend upon the extent to which the ether reservoir is made to rotate upon the whistle-shaped tube, and this extent is registered by the indicator (*i*). With the indicator at 'o' the current is a wholly direct one, passing backwards and forwards to the bag without entering the ether chamber (Fig. 32). With the indicator at '1,' one quarter is indirect, *i.e.*, passes over the ether, and three quarters are direct, *i.e.*, pass to and from the bag without being deflected. With the indicator at '2,' two quarters are indirect, and two quarters direct. With the indicator at '3,' three quarters are indirect, and one quarter direct. With the indicator at 'F' or 'FULL,' four quarters (*i.e.*, the whole of the current) are indirect, and pass over the ether in the chamber.

The sectional drawings of Figs. 30 and 31 apply to the ordinary pattern of Clover's inhaler. Two slight modifications deserve notice. (1.) Owing to the small extent of bearing at the end of the whistle-shaped tube, ether vapour is prone to gain admission into this tube, even though the indicator points to 'o.' To obviate this the central tube has been made of a totally different shape[1] (Fig. 33), and the holes or slots in the shaft have been correspondingly altered. From the accompanying sectional drawing of this inhaler it will be seen that the half-diaphragm D is placed at right angles to the shaft. The tube T works up against this half-diaphragm. T has in its circumference two large slots (S*l*). It is also furnished with a half-diaphragm, D′, which

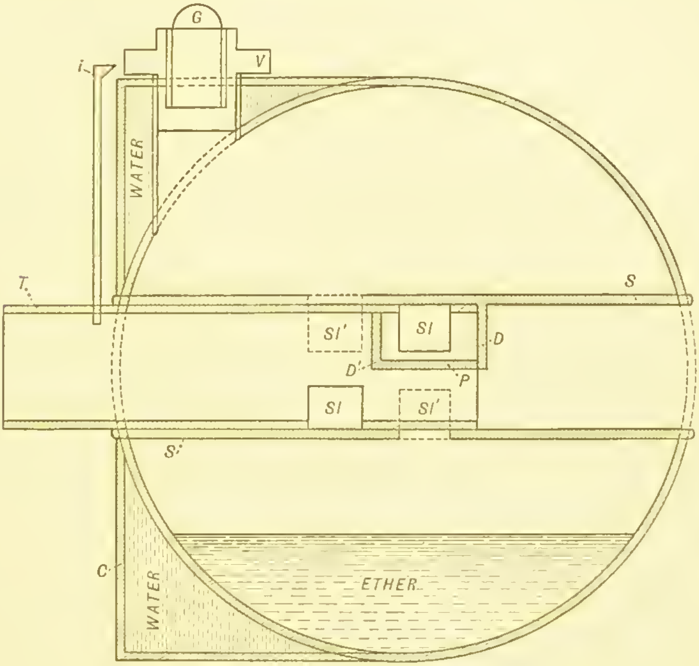

FIG. 33.—Section of a Modified Clover's Ether Inhaler. (Two-thirds actual size.)

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[1] This improvement was introduced by Messrs. Barth & Co.

joins a plate P passing to the end of the tube. When T is in position the plate P meets the fixed half-diaphragm D. In the shaft S there are two slots (Sl′) which are shown in dotted outline. These slots (Sl′), which open into the ether chamber are accurately and thoroughly closed by the ample bearing of T. When the ether-reservoir rotates on T, the slots Sl′ gradually communicate with the slots Sl, and the current is thus made to pass over ether to any desired extent. This particular fitting is advantageous when administering nitrous oxide through Clover's ether reservoir (see p. 184); for, by reason of the ample bearing, ether vapour does not escape into the tube when the indicator is at 'o.' (2.) It is necessary during the administration of ether by Clover's apparatus to frequently ascertain whether enough ether is present. I therefore devised the little stopper shown in Fig. 33. The orifice of the filling-tube is made flush with the surface of the reservoir. The vulcanite plug (V) terminates in a short glass tube (G) closed at one end. The level of the ether in the apparatus can thus be easily ascertained without removing the stopper.

Directions for using Clover's Portable Regulating Ether Inhaler.

1. *Pour out any ether that may have been left from a previous administration.*

2. *In cold weather partially immerse the ether reservoir in warm water for a few minutes before use.* This is very important, and absolutely essential to success when anæsthetising patients who are likely to require considerable quantities of the anæsthetic (tall muscular men, alcoholics, &c.). The water used for warming the apparatus must not be too hot.

3. *Pour in through the filling tube 1½ ozs. of ether, replace the stopper or cork, and turn the indicator to* 'o.'

4. *Fit on a face-piece of appropriate size; and blow out through the apparatus, in order to expel all traces of ether vapour that might possibly be present in the shaft of the apparatus.*

5. *Gently but accurately adapt the face-piece to the face of the patient; and request him to breathe in and out quite freely.* By telling the patient that he is simply breathing air he will gain confidence and breathe without hesitation.

6. *When the patient is breathing freely attach the bag to the ether reservoir.* This should be done during an expiration in order to fill the bag, more or less, with the patient's own breath. As a general rule it is necessary to catch several expirations in order that the bag may be filled before starting. All that is needed is to press the face-piece more tightly during expiration than during inspiration, and the bag will then fill.

7. *Allow the patient to breathe backwards and forwards for*

about half a minute before turning on any ether vapour. This is perhaps the most important step in the administration. To apply the apparatus with the indicator at any other place than '0' is wrong; and it is equally wrong to commence the rotation of the ether reservoir till the patient has been breathing his own expired air backwards and forwards for the time mentioned. Should the breathing be unsatisfactory, or the breath be held, the patient should be encouraged and told to 'blow out' into the bag. Forcible expiration must be followed by a correspondingly deep inspiration. Should the patient have a beard or moustache the face-piece must be pressed very tightly to exclude all atmospheric air. Having once got the bag sufficiently full of expired air the administrator should not raise the face-piece from time to time to admit fresh air. This procedure is, of course, necessary later on, but is quite wrong at the present stage of the inhalation. The bag should freely expand and contract as the patient breathes. Each inhaler emits a characteristic sound when the face-piece fits well and the breathing is free; and the administrator should attempt to secure this sound with each case.

8. *Having allowed the patient to breathe his own expirations backwards and forwards for the time mentioned, very gradually rotate the ether reservoir so that the '0' on its circumference moves almost imperceptibly but yet continuously away from the indicator.* If the patient's head be on its right side the administrator should grasp the face-piece with his right hand and have his left free for the almost continuous rotation of the reservoir. As a general rule about one-eighth of an inch of the circumference of the reservoir may be moved away from the indicator every breath or two. Should the administrator rotate the reservoir too quickly, swallowing, holding the breath, coughing, or retching will be likely to result. Should the patient swallow or hold the breath the reservoir should be turned back till breathing is again regular. Respiratory rhythm is nearly always interfered with to a slight extent by an occasional act of swallowing or a temporary holding of the breath. But after about 1½ minutes the breathing (usually quite suddenly) becomes regular and deeper. This change in the character of the respiration is probably simultaneous with loss of consciousness. The administrator should take advantage of this deeper respiration to turn on ether somewhat more freely than before; *i.e.*, he may rotate the ether reservoir rather more rapidly, but the rotation should never be rapid enough to excite cough. It should not be in jerks, but should be progressive. Up to this time no fresh air has been admitted, and if the face-piece fit as it should do, the colour of the face will be growing a trifle dusky.

9. *Fresh air should not be given till there is a distinct indication*

for it. Moderate duskiness or lividity is not of itself an indication for fresh air at this period. But should this symptom be associated with any impairment of respiration or circulation, air should at once be allowed. Healthy and florid subjects quickly become dusky with Clover's inhaler properly used. If a breath of fresh air be admitted early in the administration simply because the patient is dusky, he will almost certainly come round sufficiently to hold his breath, swallow, set his teeth, or cough, and difficulties will be likely to be thus initiated. No attention should be paid to the duskiness, as a general rule, till stertor has commenced. At this time, usually two to three minutes from the commencement, one inspiration of fresh air may be allowed, and the next expiration collected in the bag. Two or three breaths will be too much in strongly built subjects. The stronger and more full-blooded the patient the more careful must we be in admitting air, if we wish to secure good anæsthesia without excitement or struggling. The exclusion of air, as here recommended, is not so necessary, nor is it advisable, in fragile and feeble subjects.

10. *When a breath of fresh air is given the strength of vapour should be increased, otherwise the patient may come out of the anæsthesia.* We have, in using this inhaler, two factors; the ether factor and the asphyxial factor. The less air we give the less ether we shall need: the more air we admit the more ether will be required.

11. *Should symptoms of excitement arise, and struggling commence, the inhaler should be kept closely applied.* When the apparatus is properly managed, excitement and struggling are quite exceptional. When they manifest themselves they are best treated by a persistent and steady administration. The asphyxial element, which is now regarded as dangerous under chloroform at this stage, is practically without risk under ether. Still, in persons with a feeble circulation, and especially in flabby elderly people, the administrator should avoid any prolonged suspension of breathing, and should rather allow his patient to give him a little trouble by partially emerging from the state already induced, than run any risk of throwing a dangerous strain upon a disordered circulation.

12. *When the breathing has become regular and stertorous, and the conjunctiva insensitive* (these signs usually manifest themselves in about 2½ or 3 minutes) *the inhaler should be removed for two or three breaths.* The administrator will usually now be able to let his patient partially regain his normal colour. He should not, however, be in a hurry to do this. More than an inspiration or two of air may at once cause holding of the breath,

increased cyanosis, jaw-spasm, &c. It is best to have secured deep stertor for two or three minutes before giving the quantity of air needed to restore the usual colour.

13. *In ordinary cases it is unnecessary, in order to secure full anæsthesia, to rotate the ether reservoir beyond* '3.' If care be taken, and symptoms closely observed, this figure may generally be reached, without exciting cough, &c., in about 2½ minutes from the commencement. In patients requiring large quantities of ether, it may, however, be necessary to proceed as far as 'F'; and even to keep the indicator at 'F' for several minutes before complete anæsthesia is established. In the case of children, feeble subjects, &c., a proper degree of anæsthesia may often be reached without ever carrying the indicator beyond '1' or '1½.'

14. *When once full surgical anæsthesia has become established, the anæsthetist will be able to turn back the ether reservoir to* '2,' '1½,' *or even* '1,' *and to admit air in sufficient quantities to avoid cyanosis.* It is impossible to lay down any definite rules as to the position in which the indicator should be allowed to remain during the administration. Speaking generally, less and less ether will be needed as the inhalation proceeds. The proper degree of anæsthesia for the particular case must be ascertained, and the indicator arranged accordingly. Similarly, the extent to which fresh air should be allowed must vary widely. We may say, speaking generally, that the longer the administration has been proceeding the more air may we allow. The best guide as to the need for air (I am now speaking of the latter stages of the administration) is the colour of the features. When once anæsthesia has become properly established, the face-piece should be entirely removed for one or two breaths of fresh air *about every* 20 *or* 30 *seconds.* Should the asphyxial element be badly borne, or should the patient be weak or very fragile, more air than this will probably be advisable. On the other hand, should the patient tend to emerge from the ether anæsthesia, and should he be in a fair state of health, the asphyxial factor may with advantage be made use of to a greater degree.

15. *Be careful to replenish the ether reservoir before the ether in it is exhausted.* If this is not done the patient may come out of the anæsthesia whilst the inhaler is being re-charged. In patients of stalwart build and in good health it is often necessary to refill the apparatus about 5 or 7 minutes after commencing, more especially if the weather is warm, or the apparatus has been heated before use.

Ormsby's Ether Inhaler.

The Ormsby's inhaler usually supplied by the instrument-makers is constructed as represented in the accompanying diagram (Fig. 34). F is a metal (zinc) face-piece which can be bent to any desired shape. Its edge is guarded by an india-rubber pad (P), which can be inflated with air. To the other edge of the face-piece there is fixed a wire cage (C) containing a sponge (S). The bag (B) fits on to the face-piece, and its neck grasps the cage. The bag is covered with a loose netting by some makers of the apparatus. On the upper surface of the face-piece there is a circular opening (O) with a slot (S*l*) cut in its circumference. Fixed into the mouth of this opening there is a funnel-shaped tube (F*u*), which passes downwards and then divides, the two arms, which have perforated holes in them, coming into contact with the sponge. A cap (C*a*) fits over O, and like O is furnished with a slot, which may be made to correspond to the slot (S*l*) in O. When the slots correspond air will gain admission to the apparatus; when they do not correspond this communication with the air is cut off. When the cap is taken off, as in the figure, the funnel-shaped tube (F*u*) may be used for supplying ether to the sponge.

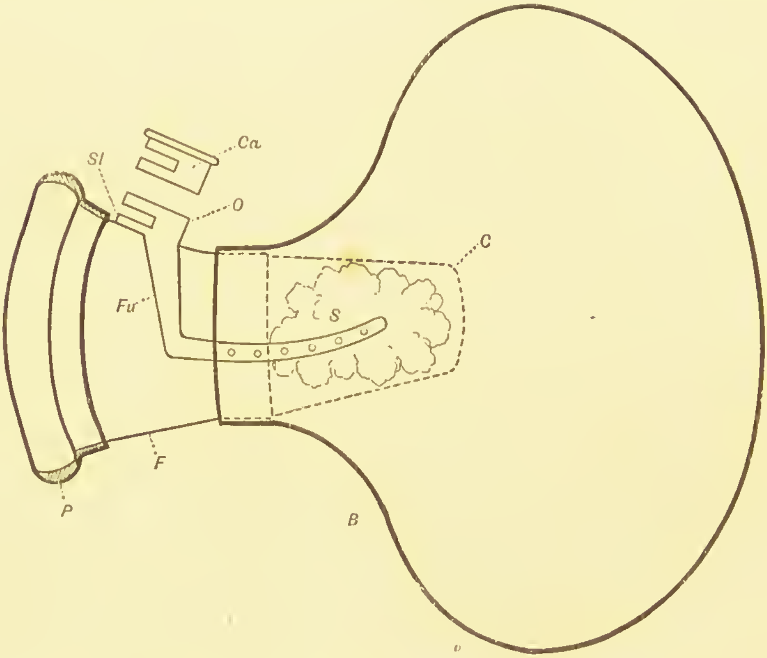

Fig. 34.—Diagram of Ormsby's Ether Inhaler. (Ordinary pattern.)

Experience with this useful inhaler has led to one or two slight modifications in its construction. In actual practice the funnel-shaped filling-tube is rarely used, for it is found to be more convenient to pour ether directly upon the sponge. Then, again, the bag usually supplied with the inhaler has proved to be far too small, especially for anæsthetising patients with full chest capacity. And, lastly, any netting over the bag is unnecessary and out of place, as free respiration may thereby be restricted. Mr. Woodhouse Braine, who prefers Ormsby's apparatus to all others for ether-giving, has therefore used for many years an inhaler possessing no filling tube and having a very capacious bag of red rubber without a network covering. The red india-rubber is little if at all affected by ether.

The Ormsby's inhaler which I myself employ is shown in Fig. 35. P represents the india-rubber pad round the face-piece; B is the bag; and *Ca* is the air-cap. This inhaler is identical in its general construction with Mr. Woodhouse Braine's pattern; but it possesses a simple internal arrangement, made for me by Messrs. Weiss & Son, for preventing the temperature of the sponge becoming too low during the administration. There has always been this objection to Ormsby's inhaler. It may, of course, be overcome by simply wringing out the sponge in hot water before commencing, by warming the body of the inhaler, by replacing the frozen sponge during the administration, or by other devices. But the best plan that I know is to have the cage of the inhaler so made that it will allow of a small portable metal water-

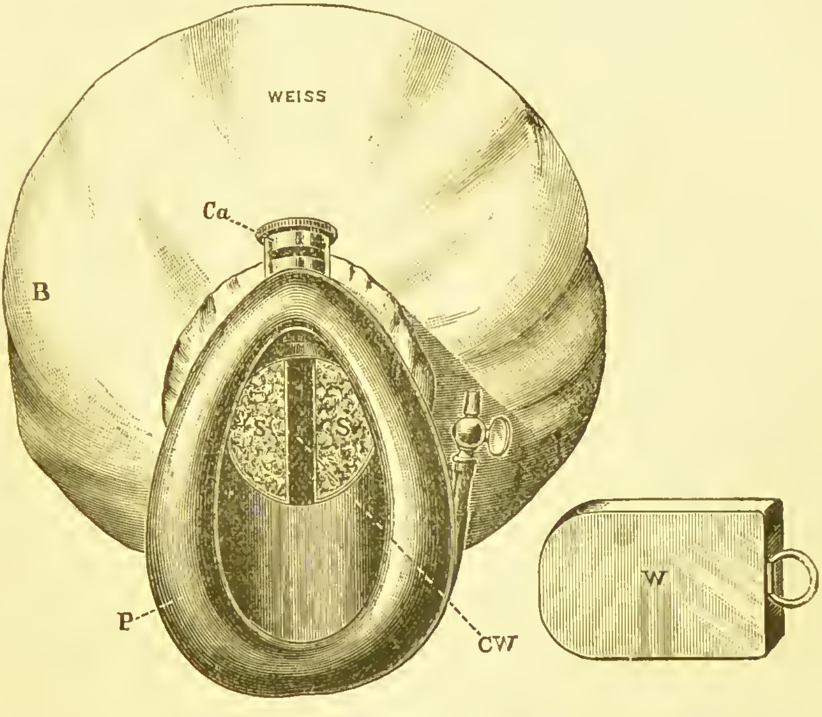

Fig. 35.—Ormsby's Ether Inhaler, with Removable Water-chamber.

chamber (W) being introduced. By having the sponge cage longitudinally divided into three compartments, and using the central compartment or space (CW) for the water-chamber, the two side partitions are left for the sponge or sponges (S). By placing the little chamber in warm water for a few minutes it takes up heat, and will thus either prevent the tendency of the sponge to freeze, or, should it have become frozen, will quickly thaw it. The chamber is not of much use in hot weather, but in winter time, and more especially when anæsthetising vigorous or alcoholic subjects, I find it of much assistance. I think, too, that when giving ether to patients in whom a liability to bronchial affections exists, the use of this contrivance may minimise the risk which might be attached to the use of this anæsthetic in such cases. If one has at hand a basin of hot water it is very easy to keep the water-chamber warm by immersing it and replacing it from time to time.

Directions for using Ormsby's Inhaler.

1. *Wring out the sponge in warm water, and, having squeezed it as dry as possible, place it in the cage.*
2. *Pour upon the sponge about half-an-ounce of ether.*
3. *Very gradually bring the inhaler towards the face of the patient, and, if an air-slot be used, see that it is open.*
4. *Encourage the patient to breathe as freely as possible, and gradually close the air-slot.* Unless the administration be conducted very gradually an intense feeling of suffocation will result. Even if care be taken, the induction of anæsthesia by this inhaler is by no means agreeable. Holding of the breath, swallowing, coughing, and a very copious secretion of mucus are common, and excitement and struggling are often met with.
5. *Be prepared for the patient attempting to push away the inhaler, rising from the bed, &c.* When once the administration has been fairly started the inhaler should not be removed for air till signs of anæsthesia are approaching, or till more ether is required.
6. *Should the sponge freeze, another one, wrung out as before, should be substituted, and fresh ether added.*
7. *When more ether is needed, about half-an-ounce at a time should be added to the sponge.*

The quantity of ether required will vary widely, and the same may be said with regard to the supply of air. The weaker the patient the greater should be the supply of air allowed. Very vigorous and alcoholic persons will require large quantities of ether, and in such subjects the air-supply may be more restricted.

Clover's and Ormsby's Inhalers Compared.

For *inducing* anæsthesia by means of ether there is no apparatus which can be compared to that invented by Clover, for the anæsthetic vapour may be admitted so gradually that the initial discomforts are reduced to a minimum. But for *maintaining* ether anæsthesia Ormsby's inhaler is equal, and in many cases superior to Clover's. I have on several occasions changed from a Clover's to an Ormsby's inhaler with marked improvement in the symptoms of the patient. For example, I have often known cyanosis to quickly vanish and the breathing to become less hampered by effecting this change of inhalers during deep ether anæsthesia. It is probable that the narrow channels through which the patient has to breathe in Clover's apparatus may be responsible for differences of this kind. But there is another explanation, viz., that during the intervals in which the inhaler is removed from the face the narrower and more circuitous channels tend to retard diffusion between the bag and the outer air. In Ormsby's inhaler there is greater chance of diffusion, and expiratory products are hence not so likely to accumulate. Clover's inhaler is preferable to Ormsby's for anæsthetising quite young children, as the quantity of ether required is very small. More ether is wasted when employing Ormsby's apparatus than when using Clover's.

Ormsby's inhaler is admirably well adapted for administering ether *after* a full inhalation of nitrous oxide (p. 180), because a sudden and considerable quantity of ether is needed within a very short space of time. But when it is desired to gradually admit ether vapour *during* the inhalation of nitrous oxide, Clover's inhaler answers extremely well (p. 184).

Ormsby's inhaler is preferable to Clover's for administering ether after a small quantity of the A. C. E. mixture (p. 256).

B. THE EFFECTS PRODUCED BY THE ADMINISTRATION OF ETHER.

Ether is now so widely employed for the production of surgical anæsthesia, that the phenomena which attend its exhibition are worthy of the most careful consideration and study. In order that this agent may be administered with success, some amount of training is absolutely essential. What one surgeon would regard as satisfactory ether anæsthesia another might consider as by no means entitled to such a favourable description. With proper attention to a few cardinal points, and with a little practice, the administrator will find that he is not only able to materially lessen the disadvantages of ether as an anæsthetic, but that he can, without danger to his patient, or anxiety to himself, induce and maintain by its means a most satisfactory form of anæsthesia for surgical operations. Although there are often little difficulties to be overcome early in the administration; although the anæsthetic may cause a degree of respiratory activity which does not contrast very favourably with the more tranquil breathing of other anæsthetics; although the air-way is more liable to become temporarily occluded than when employing chloroform; the anæsthesia from ether is as safe as one can reasonably expect profound surgical anæsthesia to be. If there is one thing concerning this valuable agent more worthy of note than another it is that, when once deep narcosis has been produced, the administrator may rest assured that, should any untimely symptoms occur, sufficient warning will be afforded him to meet them with deliberation and success. The anæsthesia of ether thus strongly contrasts with that of chloroform, under the influence of which patients not infrequently pass into a condition of some danger with but little or no warning. The moderately healthy patient under ether may be raised into the sitting posture: he may be subjected to an operation before he is very deeply anæsthetised:[1] his air-supply may be so restricted that a considerable degree of cyanosis is occasioned: and yet his circulation will not show that liability to comparatively sudden fluctuations and depressions which, whatever may be their physiological explanation, most undoubtedly occur under chloroform. In addition to these important considerations, the respiration under ether is usually so obvious and audible that any alteration in the function of breathing may be at once detected: the sleep-like and inaudible respiration not infrequently met with under chloroform is almost unknown under ether.

The phenomena of ether anæsthesia will be found to greatly depend upon the method of administration adopted. When the anæsthetic is given slowly and with a free supply of air, *i.e.*, by the 'open' method, the time taken to secure complete narcosis will be longer, and the stages of anæsthesia, if such they can be called, will be more noticeable than if moderate air-limitation, *i.e.*, the 'close' method, be practised. Owing to the rapidity and quietude with which patients become anæsthetised by ether when the air-supply is properly regulated, we do not now, as formerly, have such a favourable opportunity of studying the so-called stages of the inhalation. For many reasons, however, and more especially for the correct understanding of exceptional cases, it is well that we should continue to speak of these degrees or stages.

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[1] Although the commencement or performance of an operation during imperfectly established ether anæsthesia is not attended by that risk which obtains under similar circumstances with chloroform, such a procedure should never be adopted save in exceptional cases.

First Degree or Stage. In consequence of the pungent and rather disagreeable odour of ether, it is impossible to completely avoid all unpleasant sensations at the commencement of the inhalation. When well diluted with air, however, or cautiously administered during the re-breathing of a limited quantity of air as by Clover's inhaler, the irritant properties of the vapour will be greatly minimised. Should the vapour be too strong for the particular patient, the glottis will close, as in the early stage of swallowing, and a feeling of suffocation may ensue Should the anæsthetic be so administered that closure of the glottis, repeated acts of swallowing, and cough are more or less completely prevented, respiration will rhythmically proceed, and will become deeper and quicker than normal. Disturbances of sight, hearing, and tactile sensibility are liable to be experienced. Flashes of light before the eyes have been described. If any one is speaking in the room the voice may seem to be painfully loud and grating in character. Singing in the ears, buzzing sounds, and hammering noises have been recorded. It is a very common thing for the patient to feel a peculiar thrilling or prickly sensation throughout the body. At this stage the pulse is usually considerably accelerated; and the pupils large and very mobile. A state of analgesia is reached in which the patient, though more or less conscious of his surroundings, will not experience pain from the infliction of an injury. A tooth might, for example, be painlessly extracted during this state, the patient being all the while aware of the operation. It is hardly necessary to point out that this stage of etherisation is, as a rule, very short, more especially when a close inhaler is employed.

Second Degree or Stage.—Loss of consciousness takes place abruptly. The patient passes into a condition in which, although memory, volition, and intelligence are abrogated, he will readily respond to stimuli. The response may have all the appearance of conscious response. Questions may be answered; but the answers will probably be nonsensical. Laughing, struggling, shouting, and singing may be met with at the commencement of this stage if the administration be slowly conducted. They are more likely to occur in patients who require considerable quantities of the anæsthetic than in others. Struggling will often fail to appear if the slight restless movements of the arms and legs, which are common at this stage, be unrestrained. Holding the patient down, as well as other interferences, may readily evoke struggling. Hallucinations of sight and hearing often occur, especially when ether is slowly given with plenty of air. The pupils are still mobile, and usually more or less dilated. The muscular system is for the most part thrown into a state of tonic contraction; but clonic movements may sometimes be witnessed towards the close of the stage. In exceptional cases a fine tremor, known as 'ether-tremor,' may occur.[1] This phenomenon appears to belong more to the second than to the third stage of etherisation, seeing that it may usually be controlled by a deeper anæsthesia; so that it is here referred to. Mucus and saliva are freely secreted, especially in young and florid subjects. The features become flushed, the conjunctivæ injected, perspiration commences to break out over the face and other parts, and a harmless degree of duskiness, varying with the quantity of air admitted and with the patient's normal colour, will be observed. The pulse is quick and bounding. Any articulate language which may have been uttered becomes replaced by disjointed speech, which in its turn is followed by inarticulate muttering, and subsequently by mere syllables or expiratory noises. The breathing during this stage is inclined to be irregular and a trifle hampered, owing to the tendency to general muscular spasm. Temporarily suspended respiration may thus sometimes be met with, more especially in muscular subjects. The commonest cause for these slight irregularities in breathing at this stage is the employment of too strong a vapour. Clenching of the teeth from masseteric spasm, half-performed acts of swallowing necessarily interfering with respiration, and varying degrees of laryngeal spasm are one and all liable to arise from this cause. As the inhalation proceeds, however, the breathing grows more and more regular, and commencing stertor may be detected. Those muscles whose special office it is to carry on respiration now become incapable of being reflexly affected by the stimulus of ether, whilst others, whose spasmodic contraction would only indirectly affect the rhythm and amplitude of breathing (such as many of the muscles bounding and influencing the conformation of the upper air-passages), are now unable to interfere with free respiration, owing to their having become flaccid under the anæsthetic. In this manner the patient passes into the third stage of anæsthesia.

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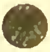
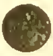
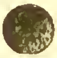
[1] I have notes of several cases of 'ether-tremor.' In four of these it was considerable. The ages of three of the patients were 21, 24, and 30 respectively; no age is recorded in the other case. In one instance (the patient aged 30) the tremor came on before the operation commenced. In the patient aged 24, a healthy and well-developed man, undergoing an operation for varicose veins, the tremor was associated with a very large pupil and some lid-reflex. Julliard (*op. cit.*) states that he has never witnessed this phenomenon in women, and also that the patients in whom tremor occurs are invariably alcoholic or extremely nervous subjects. With the latter statement I cannot agree, as I have witnessed the symptom in question in young and non-alcoholic patients.

The reader must bear in mind that when the administration is properly conducted the duration of the second stage is far shorter than the above description might suggest. When a close inhaler is used, both the first and second stages may be passed over, and deep anæsthesia reached in from three to four minutes. But for purposes of analysis we have had to picture to ourselves a slow inhalation with more air than is usually advisable. Moreover, in the above description it has been taken for granted that no surgical or other procedure which would produce pain in a conscious patient has been in progress. The influences upon respiration and circulation which may result from commencing an operation before full surgical anæsthesia has become established will be fully discussed elsewhere.

Third Degree or Stage.—When the respiration has become regular and stertorous, the cornea insensitive to touch, and the extremities flaccid, the patient may be said to have passed into the third degree of anæsthesia, and to be ready for any surgical operation.

The **respiration** during deep etherisation is, with the rarest exceptions, always forcible and distinctly audible. Owing to the almost invariable presence of a small quantity of mucus in the fauces and larynx, breathing has a moist character in addition to its usual stertor. A little tendency to spasm of the masseters and adjacent muscles may remain for a while and necessitate the lower jaw being pushed forward from behind by the administrator (see Fig. 54, p. 291). Such spasm, however, gradually subsides. The anæsthetist must bear in mind that unless he keeps up a nearly continuous administration the patient will quickly pass back into the preceding stage, and irregularities in breathing will thus become developed. The rate of respiration is always markedly increased, varying considerably in different cases, and being dependent upon numerous circumstances, foremost amongst which must be mentioned the degree of air-limitation practised. Ether stertor is most commonly due to the base of the tongue coming in contact with the pharynx, and as breathing usually takes place through the nose the stertor usually has a nasal character. Pushing the lower jaw forwards from behind at once diminishes or stops the snoring. A tendency to laryngeal closure, either from too strong an ether vapour or from operative measures upon certain parts of the body (p. 289), is not uncommon, but rarely gives rise to difficulty. Sometimes the crowing breathing will persist throughout. When dependent upon the first-named cause the spasm will subside with less of the anæsthetic; when occurring during rectal or other operations upon sensitive parts more of the anæsthetic is usually indicated. It is hardly necessary to add that the amplitude, regularity, and even the rate of breathing will depend upon the conformation and size of the upper air-passages in addition to other factors.

The **circulation** of the etherised patient gives numerous clinical indications of its remarkable fulness and force. The heart's action is excited; the pulse full, bounding, and regular; the face is abnormally flushed; and incised parts, more especially in the neighbourhood of the neck, are very vascular. The pulse is slower than it was during the second stage, but quicker than the normal. It is usually from 80 to 100 or 110 per minute, though it is not uncommon to find its rate as high as 120 per minute. The rate and force of the pulse are to a certain extent dependent upon the degree to which atmospheric air is excluded—too great a degree of air-limitation lessening the force and increasing the frequency of the heart's action. A roseolous rash sometimes makes its appearance upon the chest, neck, and other parts, when the vascular excitement is at its height. Profuse perspiration is not very uncommon.

The **pupils** of deep etherisation deserve special mention, as they differ from the chloroform pupils in some respects. They are usually of moderate size or slightly dilated, *i.e.*, from to  (3½ to 4½ mm.), and are active to light. The causes which may influence their size will be dealt with below when discussing the depth of anæsthesia necessary for surgical operations (p. 166). In certain cases in which a very deep anæsthesia is essential the anæsthetic may have to be administered till the pupil is considerably dilated, *i.e.*,  to  (5 to 5½ mm.). Kappeler found from observations upon 150 cases that the pupil was contracted in 37 during deep etherisation.

The **position of the eye-balls** during deep anæsthesia is similar to that observed under chloroform (see p. 207).

The degree to which the **muscular system** is relaxed will depend not only upon the depth of etherisation but upon the nature of the operation which is in progress. In some cases a minor degree of rigidity may persist for a considerable time. In several instances I have had occasion to believe that the muscular rigidity present in deep anæsthesia has depended upon the restriction of air, and have noticed that it has passed away with an increase in the quantity of air admitted.

It is hardly necessary to point out that the colour of the face and lips will, during this as during other stages, greatly depend upon the degree to which air is withheld.

C. DANGERS CONNECTED WITH THE ADMINISTRATION.

General Consideration.

In moderately healthy subjects the inhalation of ether is, like that of nitrous oxide, practically unattended by risk to life. The fatalities which have been reported as having occurred from the use of ether have almost invariably taken place in exhausted or markedly diseased individuals.

On looking through the *Lancet* and *Brit. Med. Journ.* for ten years (1880 to 1889 inclusive) I find 27 fatalities from ether recorded as having occurred in Great Britain during that period. In 24 of these the patients were suffering from various diseases which had seriously impaired their general health. Of the three remaining fatalities, one is so imperfectly reported as to be useless for purposes of analysis; and one can hardly be ascribed to the anæsthetic, seeing that death was caused by vomited matter entering the trachea. The only casualty which occurred from the direct effects of ether in a patient whose general health was probably, though not certainly good, would most likely have been averted by tracheotomy. The following analysis of the 27 cases may be of interest:—

TABLE SHOWING THE ETHER FATALITIES reported in the *Lancet* and *British Medical Journal* as having occurred in Great Britain during ten years (1880–1889 inclusive).

Condition of Patient at Time of Administration.	Fatalities.
GROUP 1.—*Patients suffering from some pre-existing morbid state capable of impeding respiration during anæsthesia* .	10
Empyema—2 cases (*B. M. J.*, March 13, 1886, p. 489; *B. M. J.*, April 22, 1882, p. 589).	
Pleural effusion, ascites, dilated heart, and renal disease—1 case (*B. M. J.*, Aug. 20, 1881, p. 327).	
Bronchitis, emphysema, fatty heart, and adherent pericardium—1 case (*L.*, Jan. 24, 1885, p. 178. Also reported in *B. M. J.*, March 13, 1886, p. 489).	
Cancer of lung, liver, and upper jaw—1 case (*L.*, Aug. 27, 1881, p. 386, and *B. M. J.*, Feb. 25, 1882).	
Enlarged thyroid—2 cases (*L.*, Nov. 15, 1884, p. 895, and *B. M. J.*, May 2, 1885, p. 887; *B. M. J.*, March 15, 1884, p. 508).	
Diphtheritic laryngitis—1 case (*L.*, June 18, 1881, p. 1014).	
"Cancerous growth in gums and throat"—1 case (*B. M. J.*, Feb. 23, 1884, p. 378).	
Extensive pleural adhesion and œdema of lungs—1 case (*B. M. J.*, Dec. 18, 1880, p. 1000).	
GROUP 2.—*Patients suffering from cancerous or other affections producing extreme exhaustion*	10
Intestinal obstruction—3 cases (*L.*, Sept. 4, 1880, p. 376; *B. M. J.*, Jan. 15, 1881, p. 103).	
Uncomplicated asthenia—1 case (*B. M. J.*, March 13, 1886, p. 489).	
Feeble patients with abdominal tumours—3 cases (*B. M. J.*, May 2, 1885, p. 887; *B. M. J.*, July 15, 1882, p. 103).	
Asthenia with morbus cordis—2 cases (*L.*, May 27, 1882, p. 892; *L.*, Dec. 3, 1887, p. 1132).	
Large sarcoma of chest-wall, feeble patient—1 case (*B. M. J.*, Jan. 1, 1881, p. 14).	
GROUP 3.—*Patients suffering from renal disease and morbus cordis*	3
Vesico-vaginal fistula (a coloured woman)—1 case (*L.*, April 20, 1889, p. 800).	
Extreme obesity—1 case (*B. M. J.*, Nov. 22, 1884, p. 1027).	
Diffuse cellulitis of palm and wrist—1 case (*B. M. J.*, Sept. 3, 1881, p. 414).	
GROUP 4.—*Patients in moderately good health at the time of administration*	2
Sudden cessation of respiration before operation—? cause—1 case (*L.*, Sept. 3, 1881, p. 430).	
Vomited matters entered larynx and trachea—1 case (*B. M. J.*, Sept. 3, 1881, p. 414).	
GROUP 5.—*Exhausted patient—ovarian tumour—death from pulmonary congestion seventeen hours after operation* (*B. M. J.*, May 2, 1885, p. 887)	1
GROUP 6.—*Imperfectly reported* (*L.*, Dec. 6, 1884, p. 1027) . .	1
	27

SPECIAL CONSIDERATIONS.

1. The Administration of an Over-dose: Fourth Degree or Stage.—Generally speaking, we may say that so long as the conjunctiva remains sensitive any symptoms of danger which the patient may exhibit will depend upon other causes than the administration of an over-dose of the anæsthetic. The phenomena we are about to discuss, therefore, are phenomena occurring in association with an insensitive conjunctiva.

Should the administration of ether be carried too far, respiration will commence to show signs of failure. With this indication of danger the conjunctiva will, as just mentioned, be found to be insensitive to touch; the pupil more or less dilated; the colour dusky rather than pale; the eye-lids slightly separated; and the pulse, although still remarkably good considering the respiratory depression, somewhat less forcible, and possibly slower than it was previously.

The manner in which respiratory failure occurs will vary in different cases. In the majority of instances the breathing loses its stertor, becomes feebler and feebler, and then altogether ceases. In some instances, prolonged, difficult, and rather wheezy expiration, with shallow inspiration, may be observed, and may indicate a dangerous depth of narcosis. In others, again, the regular and deep stertor which has been present may be succeeded by jerky, intermittent, and gasping breathing, during which the respiratory movements may abruptly come to a standstill.

An obstructed state of the upper air-passages, although possibly occurring in some cases as the result of too large a quantity of the anæsthetic, is probably more often associated with a light or moderately deep anæsthesia. It is, of course, quite conceivable that a falling together or spasm of the arytæno-epiglottidean folds, such as that which Sir Joseph Lister has described as arising under chloroform, may result from toxic doses of ether; but evidence on this matter is still needed (see p. 160).

Similarly, spasmodic fixity of the chest is probably more frequently associated with incomplete than with dangerously deep narcosis (see p. 160).

The all-important point concerning respiratory failure in moderately healthy patients under ether is this: *However such failure may arise, the circulation of the patient at the moment when breathing ceases is sufficiently satisfactory for remedial measures to be almost invariably successful.* In other words, when respiratory failure occurs from the administration of an over-dose of ether to a healthy patient, the pulse is usually still beating at the wrist. The heart is not likely to fail unless restorative measures are delayed for too long a period. The more or less simultaneous cessation of both respiration and peripheral circulation, from the too rapid administration of a large quantity of chloroform, is unknown with ether in moderately healthy persons.

2. Respiratory Failure occurring independently of an Over-dose.—The respiratory embarrassment which occasionally occurs in connection with the early stages of etherisation rarely gives cause for any anxiety. It usually passes away spontaneously as deep anæsthesia becomes established. As already mentioned (p. 154), masseteric spasm, swelling of the tongue and other structures within the mouth and nose, half-performed deglutition movements, and a varying degree of laryngeal spasm may one and all arise during the initial stages of ether administration, and may temporarily interfere with breathing. With ordinary care no trouble whatever will be experienced; for respiration will gradually become regular and unembarrassed. But should the administration be improperly and carelessly conducted, breathing may, in certain types of patients, cease for a considerable period, and remedial measures may be rendered necessary. Florid muscular subjects, with accurately meeting teeth, are more liable than others to difficulties in breathing of this nature. The treatment which should be adopted for the prevention and relief of arrested breathing early in ether anæsthesia is discussed on p. 290.

Laryngeal spasm under ether rarely if ever culminates in actual arrest of breathing. Inspiration may become of higher and higher pitch; less and less air may enter the lungs; the colour may grow more and more dusky; but the respiration invariably becomes re-established within a short space of time. A similar condition of laryngeal spasm is met with under chloroform; but with that anæsthetic the tendency for breathing to become completely obstructed is decidedly greater (see p. 221). The deeper and stronger thoracic and diaphragmatic movements under ether are possibly better able to overcome the obstacle presented by the laryngeal spasm than the less forcible movements under chloroform. For further remarks on this condition see p. 289.

In rare instances it has happened that breathing under ether has come to a complete standstill from spasm of the respiratory muscles—the chest being rigidly fixed. Some regard this state as resulting from a too free use of the anæsthetic; but there is good ground for the belief that, like laryngeal spasm, it most commonly arises quite independently of the administration of an over-dose. Our knowledge upon the subject, however, is imperfect. Respiration may cease with alarming abruptness, and the administrator may find it impossible either to compress or expand the chest by the usual methods of artificial respiration. This fixity of the chest has been met with under chloroform as well as under ether (see p. 222). The only case in which I have seen the condition with ether was a very remarkable one. The patient was a man of 69 years of age, whose usual pulse-rate was 30 per minute. He was only slightly emphysematous, and not bronchitic at the time. Under the influence of ether his expiration was rather strained. During properly established anæsthesia, breathing suddenly ceased; and though there was no obstruction, it was absolutely impossible to move the chest-walls one way or the other by artificial means. The pupil at the time was moderately contracted. Fortunately, breathing spontaneously re-appeared after about half or three-quarters of a minute.[1] The treatment of this condition is fully considered on pp. 309 and 312.

Just as there is a slight liability to temporarily obstructed breathing immediately before deep anæsthesia is established, so there is a chance of its occurrence during recovery, *i.e.*, at or about the time that the usual clenching of the teeth and swallowing which precede vomiting are prone to arise.

Respiratory embarrassment from these causes is always unattended, unless, indeed, it has existed for a considerable period, by symptoms of cardiac depression.

3. Circulatory Failure occurring Independently of an Over-dose.—In moderately healthy subjects primary circulatory failure under ether is extremely rare. It may, of course, arise as the result of profuse hæmorrhage or severe surgical shock; but it cannot under these circumstances be attributed to the anæsthetic. Indeed, the administration of ether tends in a great measure to prevent any such failure of the circulation—probably more so than does the administration of chloroform. The early and alarming syncope which occasionally arises at the very outset of chloroformisation, *i.e.*, before any operation has begun, is conspicuously absent when ether is used. The same, too, may be said of that form of syncope which has been repeatedly observed during the stage of excitement and struggling under chloroform. It is an interesting and highly important fact that records of moderately healthy patients succumbing with cardiac symptoms during the induction of etherisation are not to be found. Then again, when employing ether, we very rarely meet with circulatory depression due to the performance of the operation. This may be because patients under ether are, as a rule, kept more deeply anæsthetised than patients under chloroform, and hence are more protected from shock. It is probable, however, that the difference is chiefly dependent upon the protection which the ether itself affords. But that such depression may arise will be seen by Illustrative Cases, No. 35, p. 316; No. 36, p. 317; and No. 37, p. 318.

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[1] Mr. Holmes, Dr. Jacob, and others have recorded somewhat similar cases under ether. In two cases referred to in the *Brit. Med. Journ.*, March 15, 1884, p. 508, and May 2, 1885, p. 887, respiratory failure occurred in patients suffering from goitre, and although tracheotomy was performed and a free passage to the lungs opened up, the chest-walls were so fixed that they could not be moved. In both cases a fatal termination ensued. It is highly probable that the use of forced artificial respiration (p. 309) would offer the best chances in such cases as these.

4. The Passage of Foreign Bodies (Blood, Vomited Matters, &c.) into the Larynx and Trachea.—For remarks on this subject the reader is referred to Part III. Chap. II. Sect. I., B. p. 296.

5. Other Dangers.—Cerebral hæmorrhage has been known to occur during etherisation,[1] but is of extreme rarity. Still, we must not lose sight of the fact that persons with very brittle arteries run a greater risk of this accident under ether than under less stimulating anæsthetics (see p. 26).

The pulmonary and renal complications which occasionally follow the use of ether will be considered below. (G. After-effects.)

D. THE DEPTH OF ANÆSTHESIA NECESSARY FOR SURGICAL OPERATIONS.

Having fully considered the various stages of etherisation, and the dangers which may arise, we are now in a position to discuss the proper level of anæsthesia at which the patient should be kept during the performance of a surgical operation. As a general rule the administrator should endeavour to keep the etherised patient in the third stage of anæsthesia. A light narcosis, more especially in the earlier part of the administration, is liable to be attended not only by movement, but by inconvenient reflex phenomena such as spasm of the masseters, closure of the larynx, coughing, attempted vomiting, &c. There is in each case a particular and proper level of anæsthesia; and, in order that this level may be satisfactorily maintained, the administrator must repeatedly consult certain guides or landmarks which will now be considered. Although this level can be readily found and demonstrated in any given patient undergoing an operation, it by no means follows that an anæsthesia attended by similar symptoms would be appropriate in an apparently similar case. Nor must the administrator take it for granted that, because he has discovered the proper degree of anæsthesia at which to keep his patient in the early part of the inhalation, such a degree should be maintained. The tendency to inconvenient reflex phenomena seems to lessen as the inhalation proceeds; and a depth of anæsthesia which would have been out of the question at the beginning of an operation may usually be advantageously permitted later on. In deciding at what place or point we should keep our patient, we must be guided by a variety of considerations. We must bear in mind that, other things being equal, there are certain operations which demand a more profound anæsthesia than others. In the next place, there are some patients whose reflexes are so highly developed that very deep etherisation is necessary in order that good surgical anæsthesia may result. Then the point above mentioned must not be forgotten, viz., that after the operation has been in progress for some time, and more especially if much blood has been lost, and the patient is showing even slight signs of exhaustion, we need not maintain that degree of narcosis which was proper at the commencement of the case. Clinical evidence goes to show that, although a light anæsthesia under ether is not to be, for many reasons, recommended, there is not that danger in it that exists in the case of chloroform. Although reflex alterations in respiration, from the commencement or continuation of an operation during imperfect anæsthesia under ether are not infrequent, reflex circulatory depression, similar to that which may arise under corresponding circumstances with chloroform, is very rare. When the administrator has secured in his patient the usual signs of surgical anæsthesia, he must narrowly observe whether the operation has any influence in modifying these signs. By the performance of the operation another element, capable of influencing the phenomena of narcosis, will have been added. Given that the commencement of the operation has had no noticeable influence upon the symptoms of the patient, the administrator has to keep his patient as lightly under ether as is compatible with perfect tranquillity and anæsthesia. He has to find out his landmarks in the particular case before him. By carefully observing the effects produced by more and less ether upon—

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[1] See a case reported in *Amer. Journ. Med. Sciences*, 1888, New Ser., vol. 95, p. 83.

(*a.*) The respiration;
(*b.*) The occurrence of swallowing-movements;
(*c.*) The lid-reflex; and
(*d.*) The pupils;

he will have but little difficulty in deciding upon the precise place or level at which anæsthesia should be maintained. Having once established surgical anæsthesia he will find that he is able to work in one case almost entirely by the respiration; in another by the occurrence of swallowing-movements; in another by the lid-reflex; in another by the pupil; and that a few exceptional cases will remain in which he will have to draw his inferences from all these or possibly from other signs. As much of the success of the administration will depend upon a correct understanding of the changes which may from time to time occur in the signs above indicated, it may be well to consider these more in detail.

(*a*.) Of all the guides as to the depth of anæsthesia **respiration** is by far the most trustworthy. In four cases out of five the administrator will find that by observing the changes produced by more and less ether in the rate, depth, and audibility of the breathing he can easily maintain a proper degree of narcosis. When once surgical anæsthesia has become established the continued administration of ether will increase the rate, depth, and stertor of respiration, whilst the temporary withdrawal of the anæsthetic will be found to have an exactly opposite effect. In this manner it is often possible to work entirely by the sound of the respiration, giving more ether when the breathing tends to become less audible, and *vice versâ*. A puffing of the lips with expiration is common in deep etherisation. In those cases in which it occurs it constitutes a good guide as to the degree of anæsthesia, becoming more marked as more of the anæsthetic is given, and less marked, or actually disappearing, as the patient tends to emerge from profound narcosis. In some patients under ether there is an undoubted tendency towards slightly obstructed breathing, more especially when the anæsthesia is not as deep as it should be. This tendency, which is thoroughly discussed on p. 154, must always be borne in mind. It is not a dangerous tendency, because by simply keeping the lower jaw pressed forwards from behind it disappears. It is most pronounced in muscular and vigorous subjects.

In certain operations, more especially rectal, abdominal, urethral, &c. (see p. 289), a reflex laryngeal respiratory crowing is common, becoming more marked as the anæsthetic is given in smaller quantities, and less marked with a more profound degree of narcosis. This crowing respiration may, of course, have a totally different cause, *i.e.*, it may be due to too strong an ether vapour.

In many cases, and more especially in operations upon comparatively insensitive parts, and in protracted administrations, the respiration need not be kept as deep and stertorous as is generally desirable.

Sometimes an expiratory moaning sound is made, and may constitute, by its alternate absence and presence, in response to more or less ether, a valuable guide to the administrator.

(*b.*) Given that the breathing has by a free use of ether been made deep, regular, and stertorous, a temporary withdrawal of the anæsthetic will not only be followed by more tranquil respiration, but very often a tendency to swallowing, or even coughing will result, and so respiratory rhythm will become interfered with. The act of swallowing, easily recognised by allowing the fingers to rest over the larynx, is sometimes the first indication that the patient is emerging from deep anæsthesia, and when it occurs the administrator should at once give a little more ether if he wishes to avoid the coughing, straining, and vomiting which may follow.

(*c.*) The lid-reflex, *i.e.*, the closure of the eye-lid when the conjunctiva or cornea is touched by the finger, although regarded by many as an untrustworthy guide, is in my own experience a most valuable indication of the depth of anæsthesia. In order that it may be properly made use of, the administrator must remember three facts. In the first place, it very commonly happens that, although no lid-reflex can be elicited by touching the margin of the lids or the conjunctiva covering the sclerotic, a brisk closure will follow the application of the finger to the *cornea.* In the next place, the conjunctiva, by being repeatedly touched, loses its sensibility. And lastly, there are degrees of this reflex, so that the patient may require to be kept at a stage of anæsthesia bounded on the one side by considerable and on the other by very slight lid-reflex. It is sometimes easier to feel than to see a minor degree of lid-closure in response to touch. Moreover, when from having frequently touched the conjunctiva of one eye its sensibility has become diminished, the other eye may be tested. It is a good plan, indeed, to keep one conjunctiva, as it were, in reserve. Whether or no the administrator should allow the lid-reflex to be present must depend upon the behaviour of the patient when he is permitted to display a slight degree of this reflex. Generally speaking, an occasional glimpse of the lid-reflex is to be recommended, save, perhaps, during operations upon very sensitive parts, and in patients whose reflexes are highly developed. In anæmic and weakly subjects, and in long operations, lid-reflex may usually be permitted, and will be found to be perfectly compatible with satisfactory anæsthesia.[1]

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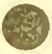
[1] The presence or absence of lid-reflex seems to be not only dependent upon the degree of anæsthesia, but upon the nature of the operation which is in progress (see p. 239).

(*d.*) If carefully watched and studied the pupils will, in most cases, afford valuable information to the anæsthetist. As the third stage of anæsthesia becomes fully established they lose the mobility which they displayed in the first and second stages, and gradually settle down, so to speak, to a particular size for the particular case. The anæsthetist should pay no attention whatever to the pupil till other signs have testified to the presence of surgical anæsthesia. He should then notice whether any reflex dilatation takes place when the operation is commenced. Should the patient be very deeply under the anæsthetic no such dilatation, or very little, will as a rule result. Should such dilatation have taken place, it will usually gradually subside, but it may persist. The pupil will be of little service as a guide until after about a quarter of an hour from the beginning of the administration. The anæsthetist may now watch its behaviour with more and less of the anæsthetic, and he will usually have but little difficulty in deciding what size of pupil indicates proper anæsthesia in the case before him. We have already seen that the average pupil of deep etherisation is one of moderate size, ● to ● (= 3½ to 4½ mm.); but in some patients a smaller, and in others a larger may be seen during satisfactory narcosis. The anæsthetist will usually observe that if he gives less ether, the proper pupil of the particular case will get smaller; if he increases the depth of etherisation it will grow larger. He will thus be able to avoid on the one hand too light, and on the other too deep, a narcosis. He will see, for example, that if he allows a pupil of ● (= 4 mm.) to come down to ● or ● (= 2 or 2½ mm.), the patient will commence to swallow, strain, or show indications of cough. But the pupil does not always diminish in size in response to less ether, and increase in size in response to more. The matter is complicated by the frequent tendency of the pupil to grow large from reflex irritation caused by surgical or other procedures. This tendency is more marked when a light anæsthesia is maintained. Now, should this tendency to reflex dilatation be present, we can readily understand that it would be checked, in other words, the pupil would grow smaller by *more* of the anæsthetic. Neurotic and anæmic subjects, as well as children, not infrequently exhibit a great susceptibility to reflex dilatation of the pupil throughout. In old people, on the contrary, and in those whose reflexes are not so highly developed, the pupil is less likely to fluctuate in size, and is usually smaller. Moreover, operations in the neighbourhood of sympathetic nerves are particularly prone to induce dilatation. This reflex enlargement of the pupil may be distinguished from what we may call the true ether dilatation by observing the effects of more and less of the anæsthetic upon it. Suppose, for example, that the patient is undergoing an operation, and that his pupils are (= 5 mm.). The question will arise: Are these pupils of reflex origin, or are they due to a deep anæsthesia? The problem may perhaps be solved by consulting the lid-reflex and other guides; but it may be more certainly settled by observing whether the pupil grows smaller or larger with less ether. If it becomes smaller with less ether the previous dilatation was probably due to a very profound anæsthesia; if it becomes larger with less ether the previous dilatation was probably of reflex origin. These considerations explain the apparent anomaly of an increased quantity of ether producing in one case a larger and in another a smaller pupil. An increase of ether will cause an ether pupil to enlarge, and a reflex pupil to become smaller. Carrying the matter one step further the reader will see that, supposing the patient to possess a pupil of  (= 5 mm.), and the dilatation to be of reflex origin, more ether will first of all bring the pupil down to say (= $3\frac{1}{2}$ mm.), and then, should the administration be continued, will cause the pupil to again dilate to (= 5 mm.), but this last dilatation will be the dilatation of very profound anæsthesia. The progressive diminution in the size of the pupil, which may often be observed in a long operation, is probably due to the progressively lighter narcosis and the more liberal supply of air which are found to be permissible. Finally, we must bear in mind the fact, when considering the pupil under ether, that any marked deprivation of oxygen will tend to effect an additional increase in size. The pupil becomes of great value as a guide when other indications as to the depth of anæsthesia cannot be readily obtained. In administering an anæsthetic one is sometimes in doubt as to the precise depth of anæsthesia at the moment, and under these circumstances the pupil will usually be of considerable service. To rely upon it altogether would be wrong: it is principally of use as a corroborative landmark.

A word may be said as to the proper depth of ether anæsthesia in infants. As already mentioned, infants take ether well if care be exercised. The administration should be slowly conducted, plenty of air given, and a diluted vapour employed. The lid-reflex cannot be depended upon; it is usually lost very early. Regular and noisy breathing is one of the best indications as to readiness for operation; but absence of rigidity (more especially during any surgical interference) is also of great value as a guide. Any tendency towards tonic spasm of the fingers or arms should be met by more ether. Fixity of the globes is usually present: should the eyes roll about and the lids be open anæsthesia is imperfect, even though respiration is deep and regular. Very high-pitched stridulous breathing usually, though not invariably, indicates rather too light an anæsthesia. (See Illustrative Case, No. 10, p. 174.)

E. AFTER-EFFECTS.

Should the administrator have carefully observed the phenomena displayed by his patient during deep anæsthesia, and have noted the changes in the respiration, lid-reflex, pupils, and other signs from time to time when less of the anæsthetic has been given, he will be in a position to foretell the order in which the symptoms of returning consciousness will manifest themselves. As a general rule distinct signs of recovery should be evinced soon after the withdrawal of the anæsthetic. Should the patient be left undisturbed his respiration will become more tranquil, his pupils progressively smaller, his lid-reflex active, and a tendency to swallowing or possibly to slight coughing will be noticed. Recovery will take place more speedily and satisfactorily, as pointed out (p. 328), when the patient is turned over upon his side. Ether is often given in unnecessarily large quantities, the patient being saturated, as it were, with the drug. A prolonged stupor, unattended by cough, and characterised by slight duskiness and deterioration of pulse, may follow this injudicious and excessive use of ether. A minor degree of duskiness after this anæsthetic is not uncommon, and appears to be connected with the presence of mucus in the air-passages, and with the quieter breathing following the withdrawal of ether. Directly coughing or retching occurs the patient's normal colour becomes restored.

The **nausea, retching,** and **vomiting** which often ensue are worthy of special remark. There is little doubt that distressing after-effects from ether are most frequently connected with too recent a meal. (See "Preparations for the Administration," p. 74.) It is true that some patients are invariably greatly upset by ether, however carefully the diet may have been regulated. But a great deal may be done to avoid subsequent nausea and malaise by properly preparing the patient. Moreover, in my experience at least, ether-vomiting is less likely to be induced by administering the purest ether than by employing ether prepared from methylated spirit (p. 7). Taking one case with another, transient retching with the expulsion of a small quantity of colourless or yellowish fluid is the rule rather than the exception. This so-called 'vomiting' after ether is almost characteristic of the use of the drug. It comes on suddenly, is violent for the moment, and rapidly subsides, leaving the patient either dazed, half-conscious, and looking about him, or still unconscious and in a quiet sleep. A short administration is followed by a quick recovery, and *vice versâ.* As a general rule ether-vomiting takes place and is passed over whilst the patient is unconscious, and it is exceptional for any recurrence to take place. It thus frequently happens that the patient is quite unaware of having vomited at all. In some cases, however, the vomiting of mucus and biliary fluids is repeated; but it is rare to meet with the distressing and often intractable sickness which occasionally follows the exhibition of chloroform. Moreover, the transient ether-vomiting is rarely if ever associated with that degree of pallor and pulse failure which are sometimes observed under similar conditions after chloroform. Imperfect anæsthesia, attended by much swallowing, is possibly more likely to be followed by protracted nausea than a deeper narcosis; although it must be confessed that cases occur in which unusually severe after-effects follow the proper and free use of the anæsthetic in patients whose diets have been carefully regulated beforehand. Looked at from all points of view we may say that the so-called 'vomiting' which follows the use of ether, although common, is hardly of sufficient importance to deserve the name; and that, putting exceptional cases aside, it rarely causes inconvenience to the patient or anxiety to the surgeon.[1]

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[1] Clover met with vomiting once in every 7 or 8 cases, but it is probable that minor cases of nausea are not included. Dr. Julliard (*op. cit.*) observed it in 314 out of 3654 ether administrations (= 1 in 11 or 12). He does not state, however, whether he includes cases of transient ether nausea. Probably he does not. Dr. E. H. Jacob, of Leeds (*Lancet*, Oct. 11, 1879, p. 539), recorded 1200 cases in which he used ether. He states that in no case was there severe vomiting. One patient in every five vomited before leaving the theatre, and a few others vomited afterwards. Mr. W. Rigden (*Lancet*, Oct. 31, 1874, p. 620) took notes of a considerable number of ether administrations, and met with vomiting in 50 per cent. of the cases, but in 35 per cent. it was very slight. It was noted as considerable in 15 per cent. He found that vomiting after ether lasted a shorter time than that after chloroform. Mr. A. Fausset (*Lancet*, June 18, 1892, p. 1386) found that, putting aside abdominal sections, 47 out of 68 (= two-thirds) of the etherised patients at the Chelsea Hospital for Women vomited after the operation. In 21 cases (= one-third) no vomiting occurred. In 21 abdominal sections 18 vomited after ether. But it does not appear that *pure ethylic ether* was used for the administrations.

With regard to the occurrence of **affections of the air-passages** (bronchitis, pulmonary œdema, and pneumonia), after the use of ether, there has undoubtedly been gross exaggeration. In many of the cases in which these sequelæ have arisen, it is probable that other causes, such as prolonged exposure upon the operating-table, the presence of commencing or undiscovered catarrh before the administration, or incautious ventilation afterwards, were responsible. When ether is properly administered to appropriate cases the danger of such after-effects is infinitesimal.

During the last ten years I have only met with two cases in which any definite bronchial irritation followed the use of ether. In one of these the patient had a cough before the operation, but her chest was unfortunately not examined. In the other the patient had had bronchitis a few months previously, and on the morning of the operation was seized with pain in her side, for which she was stethoscopically examined by a well-known physician with a negative result. Ether was administered, but she did not take it as well as could be wished. As she was kept under opium for a couple of days after the operation (oophorectomy) she did not cough, though she complained of some difficulty in breathing. Immediately the sedative was discontinued she commenced coughing, and for a couple of days expectorated freely from her larger tubes. At the end of this time the symptoms subsided.[1]

Albuminuria, nephritis, and **uræmia** have been known to follow the use of ether. In the cases in which these sequelæ have been observed, however, previous renal disease would seem to have been present. There can be no doubt that the dangers of such complications have been greatly exaggerated, and that in moderately healthy subjects, at all events, we may disregard their possibility.[2]

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[1] Of the twenty-seven ether fatalities alluded to on page 158 one only is ascribed to this complication.

Of Dr. E. H. Jacob's 1200 cases he states that three subsequently suffered from slight bronchial irritation, and of these one had had bronchitis before. Dr. Saundby (*Lancet*, vol. ii. 1880, p. 810) records a death from acute pulmonary œdema, which, as it came on after ether, is said to have been caused by it.

[2] Roux (see Julliard, *op. cit.*, p. 37) has studied the action of ether upon the kidney, and has only met with after-albuminuria four times in 119 cases; and in all these previous albuminuria existed. Dastre (*Les Anesthésiques*, Paris, 1890) also agrees with the infrequency of these sequelæ. Fueter (*Klinische und Experimentelle Beobachtungen über die Aethernarkose*, p. 28) has found in his experiments with ether that, even in prolonged administrations, no albuminuria or any other allied symptom resulted. Patein (*Thése de Paris*, 1888), indeed, has found passing albuminuria once in every three cases after chloroform. Dr. Buxton (*Brit. Med. Journ.*, Nov. 21, 1891, p. 1091) also agrees that the danger of nephritic complications from ether has been much overestimated, and states that he has administered this anæsthetic in a large

Transient **mental and muscular excitement** may arise after ether; such a condition is most common in hysterical, neurotic, and alcoholic subjects, who have been but a short time under the anæsthethic. Temporary **dementia**, which, however, was followed by complete recovery, has been recorded.[1] **Choreiform movements**, in one case lasting as long as three weeks, have also been reported as having occurred after the inhalation.[2] **Hemiplegia**, the result of cerebral hæmorrhage, has, in very rare cases, followed the use of this anæsthetic.

Lastly, **jaundice** is stated to have been produced by the administration of ether.[3]

F. RECTAL ETHERISATION.

Rectal etherisation seems to have been first suggested by Roux in 1847;[4] and Pirogoff practised it upon the human subject in the same year. The chief object in view was to facilitate the performance of operations within and about the mouth, nose, and pharynx. Liquid ether, sometimes mixed with water, was at first used; but it was soon found that more satisfactory results followed the employment of ether vapour. Within more recent times the practice has been revived by Axel Yversen and Mollière. The latter has given the method a fairly extensive trial,[5] and speaks well of it. He first tried Richardson's hand-bellows for introducing the ether vapour, but afterwards, in five cases, used an india-rubber tube which was connected with a bottle of ether immersed in water at 122° F. The ether vapour was allowed to gradually enter the rectum. As a rule, not more than 2 ozs. of ether was used. After 5 to 10 minutes a taste of ether was experienced by the patient, and drowsiness was felt. The rectal administration was supplemented by inhalation if necessary. Excitement was rarely met with. In the same year Dr. Weir[6] published a case in which rectal etherisation proved fatal. The patient was a child of eight months; the operation was for hare-lip. Less than 2 ozs. of ether was used. Depression, followed

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number of cases in which renal disease has pre-existed, and in many operations upon the kidneys themselves. For further information see also 'Artificial Anæsthesia,' by Dr. L. Turnbull, p. 252; 'Annals of Surgery,' vol. vi. p. 327; *New Orleans Med. and Surg. Journ.*, Aug. 18, 1887; and *Brit. Med. Journ.*, June 2, 1883, p. 1082.

[1] See Dr. Savage's paper: *Brit. Med. Journ.*, Dec. 3, 1887, p. 1199.

[2] See Dr. Jacob: *Lancet*, Oct. 16, 1879, p. 539.

[3] See Murchison: 'Diseases of the Liver,' 2nd edition, p. 407.

[4] *Journal de l'Academie des Sciences*, 1847, p. 146.

[5] *Lyon Medical*, April 28, 1884.

[6] *New York Med. Record*, May 3, 1884.

by melæna, supervened, and the child died next morning. Dr. W. T. Bull[1] also published seventeen cases. Melæna occurred in seven of these. Numerous other trials of the method have been recorded.[2] In some of these profound and prolonged stupor with cyanosis, contracted pupils, and asphyxial symptoms have occurred. Quite recently Dr. Buxton has employed rectal etherisation for certain cases, and finds it "to answer admirably for operations about the mouth, nose, and post-buccal cavities, for intra and extra laryngeal operations, for staphyloraphy, and for operations for the relief of empyema."[3] He has also used the method for operations upon the tongue and jaws with success, and states that the plan gives greater facilities and freedom to the operator than any other with which he is acquainted. He employs an apparatus similar to that of Mollière, and finds that a temperature of 120° F. (for the water round the ether bottle) answers well. Further experience with the method is, however, necessary. If the risk of diarrhœa, melæna, and after-stupor could in any way be greatly reduced, rectal etherisation would be strongly indicated in certain cases. It would doubtless prove of great value not only for many mouth, nose, and jaw operations, but for operations upon patients suffering from obstructed or embarrassed breathing. As already pointed out (p. 23), these latter patients are particularly bad subjects for anæsthetics, at all events when administered by the air-passages. But as matters stand, rectal etherisation has too many objections attached to it to warrant us in employing it save in very exceptional cases.

G. ILLUSTRATIVE CASES.

In the three following cases, which I have selected from my note-books, as illustrating various points to which reference has been made, the '*close*' method of etherisation was adopted.

Illustrative Case, No. 5.—F., æt. 63. Looks about 52. Grey hair. Not nervous. Good chest expansion. Regular heart sounds. Pulse not markedly accelerated. Average build—neither thin nor stout. Operation, dilatation of cervix uteri, &c. Duration 40 min. Administration commenced 9.35 A.M. Gas and ether given by Mr. Braine's method (p. 180). 'Pure methylated ether' used. Operation begun at 9.40. At 9.44 respiration 41 per minute, pulse 70, of good volume, pupils ● (= 2 mm.). At 10 A.M. (more deeply anæsthetised) pupils ● (= 2½ mm.), pulse 80, practically no conjunctival reflex. Respiration deep and stertorous throughout. Had to keep lower jaw pressed well forwards. No reflex movement or crowing breathing during operation. Gradually the pupils grew smaller, ● or ● (= 1½ or 2 mm.). More ether made pupils ● (= 3 mm.). Less ether brought them back again to smaller size. They were never larger than ● (= 3 mm.). After anæsthetic withdrawn cough occurred and retching movements. Pulse became fuller than it had been, and 80 per min. Vomiting continued for three hours, and was relieved by 15 gr. of bicarbonate of soda in hot water.

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[1] *New York Med. Record*, May 3, 1884.

[2] See *Med. Times and Gaz.*, June 7, 1884 (quoted in *Practitioner*, vol. xxxiii. p. 58); also *Brit. Med. Journ.*, Oct. 3, 1885, p. 659.

[3] *Op. cit.*, p. 86.

Illustrative Case, No. 6.—Same patient as above. Has been in bed since last operation, six weeks ago. General condition good. Operation 2.30 P.M. Removal of uterus *per vaginam.* Administration lasted 1 hour 50 minutes. Gas and ether as before, but with pure ethylic ether instead of 'pure methylated ether.' Took gas and ether well. At 2.45 (¼ hour after commencement of inhalation) conjunctival reflex just present, and pupils ● (= 2 mm.). Snoring breathing due to tongue. Very little mucus. At 3 P.M. I found patient did well with a moderately deep anæsthesia, *i.e.*, loud snoring breathing and distinct lid-reflex. At 3.30 lid-reflex present, good respiration and pulse, pupils ● (= 2½ mm.). Stertor now only present when lower jaw pressed backwards. Pulse 90. 3.31. Uterus removed. 3.40. Brisk lid-reflex, pupils ● to ● (= 2 to 3½ mm.), quieter breathing, occasional act of deglutition. 3.48. Tendency to clench teeth. 3.52. Pulse 108. 4.10. Operation over. 4.13. A cough. Patient in lithotomy position all the time, but colour always good. She had had portion of mutton chop at 8 A.M., and a little brandy and water at 12 mid-day, *i.e.*, 2½ hours before operation. She coughed up a little mucus soon after operation. Much less vomiting than on previous occasion.

Illustrative Case, No. 7.—F., æt. about 44. Average height, rather thin, florid complexion, grey hair, very good heart sounds and chest expansion. Operation abdominal section (exploratory). Administration lasted 1 hr. 12 min. Gas and ether by method described on p. 184. Seven ounces of pure ethylic ether used. 9.38 A.M. administration commenced. No difficulty. Breathing soon became stertorous. Operation commenced whilst pupils were ● (= 4 mm.) and slight lid-reflex present. The breathing, which had been stertorous, was quieter from not having kept up a sufficiently free administration. Pupils became larger with incision. A sudden cough now occurred with an attempt at vomiting. This showed that an error had been committed in not keeping the patient deeply enough under. Cough quickly allayed by more ether. 9.51. Deep stertor, pupils ● (= 4½ mm.), and no lid-reflex. Quick full pulse. Some mucus. 10.12. Pupil ● (= 3 mm.), with deep regular breathing and no lid-reflex. This pupil was obviously the proper pupil for this case at this juncture. It gradually became smaller. 10.30. Pupil ● (= 2 mm.), pulse 112, questionable lid-reflex. Less ether made pupil ● (= 3 mm.), and led to slight lid-reflex and tendency to cough. More ether had opposite effects, causing a *smaller* pupil. 10.50. Operation and administration over. Florid colour. No nausea or vomiting after.

The advantages of ether gradually given with plenty of air upon an '*open*' inhaler are shown in the three following cases:—

Illustrative Case, No. 8.—M., æt. about 37. Thin; feeble; right lung useless; pus coughed up daily; also purulent discharge from old empyema incision; left lung apparently healthy; temperature elevated; quick pulse. One ounce of brandy, with an equal quantity of water, five minutes before administration. A small quantity of A. C. E. mixture given for a minute or two; then ether (Robbins's pure ether) on an open inhaler. No difficulty whatever. Little if any cough. Allowed a little movement occasionally. (I have omitted to note the nature of operation, but I believe a portion of rib was removed.) The patient had been anæsthetised twice before with the A. C. E. mixture, and I was informed his breathing had ceased on each occasion.

Illustrative Case, No. 9.—F., æt. about 52. Stout. Sitting up in bed. Cannot lie down. Has morbus cordis, and is subject to attacks of angina pectoris and cyanosis. Pulse very feeble and irregular at wrist. (Precise nature of cardiac affection not ascertained.) Wheezing sounds at bases of lungs. Anæsthetic required for passive movement of stiff shoulder. Commenced with a small quantity of A. C. E. mixture (two minutes' inhalation) on an open felt cone, and then gave ethylic ether on same inhaler. Very gradual administration. Respiration grew deeper. An occasional cough. Conjunctiva never insensitive, though once nearly so. Colour always good. Pulse improved when under ether. Manipulations of shoulder lasted six minutes. Came round gradually with moaning respiration. No cyanosis. Satisfactory recovery from effects of anæsthetic.

Illustrative Case, No. 10.—Infant, seven weeks old. A rather weakly but not anæmic child. Was at the breast three hours before. Circumcision. Commenced at 9.45 A.M. with Robbins's ether. Administration 15 min. Ether dropped on to Skinner's mask. Some crying, lasting 2 or 3 minutes. Mask now kept fairly wet with ether. No cough or prolonged holding of breath. By degrees respiration more regular and of higher pitch. Then quite regular. Arms a trifle rigid. Very slight movement of legs. Operation begun. Trifling reflex movement and crowing breathing. Respiration, as a rule, regular and noisy; inspiration and expiration attended by similar sounds. No mucus. Pupils ● (= 3 mm.). Flaccid. No conjunctival reflex. Pulse full and quick. Face very red. About $\frac{1}{2}$ drachm of ether now added at a time. The following were the indications of "coming round":—Commencing rigidity of arms; hesitating breathing; movement of legs; and then phonation. Quick recovery. No vomiting when I left.

CHAPTER III.

NITROUS OXIDE FOLLOWED BY ETHER.

We are indebted to Clover for the valuable suggestion and practice of administering nitrous oxide before ether. The former agent is a particularly appropriate one for *inducing* anæsthesia. It is by no means unpleasant to inhale: it rapidly destroys consciousness: its administration is not attended by excitement or struggling: and its use is practically free from risk to life. Although ether, as we have already seen, is the best anæsthetic for ordinary surgical work, the sensations which attend its administration are distinctly disagreeable. Nitrous oxide therefore supplies the very qualities in which ether is deficient. From the point of view of the patient it is a great boon not only to be quickly rendered unconscious, but to be spared the suffocative and other feelings which may attend the initial stages of etherisation. Moreover, ether is a particularly appropriate anæsthetic to administer in conjunction with or immediately after nitrous oxide, because the exclusion of atmospheric air, which is essential in the case of the former anæsthetic, is to a certain extent advantageous in the case of ether. In other words, we may pass from deep nitrous oxide to deep ether anæsthesia without admitting that quantity of air which would be absolutely essential were we dealing with chloroform.

Clover's first plan[1] for administering this mixture was to render the patient unconscious with nitrous oxide, and then to change the gas inhaler for an ether apparatus. His next method was to first administer nitrous oxide by itself, and then to gradually add ether by causing the gas to pass over this anæsthetic. After working at the subject for many years he perfected his combined gas-and-ether apparatus described below.

At the present time there are three satisfactory methods of administering nitrous oxide with ether, all of which have stood the test of time and are therefore deserving of notice. The two anæsthetics may be given in succession :—

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[1] *Brit. Med. Journ.*, July 15, 1876, p. 74.

(1.) By Clover's combined gas-and-ether apparatus;

(2.) By the ordinary nitrous oxide apparatus and an Ormsby's ether inhaler; and

(3.) By fitting a special form of stopcock to Clover's portable regulating ether apparatus.

I have tried all the other plans which have been suggested, but in some point or another they are inferior to those here mentioned.

A. THE ADMINISTRATION BY MEANS OF CLOVER'S COMBINED GAS-AND-ETHER APPARATUS.

The original models of this inhaler differed slightly from that shown in Fig. 36, which represents the apparatus now employed.[1] It consists

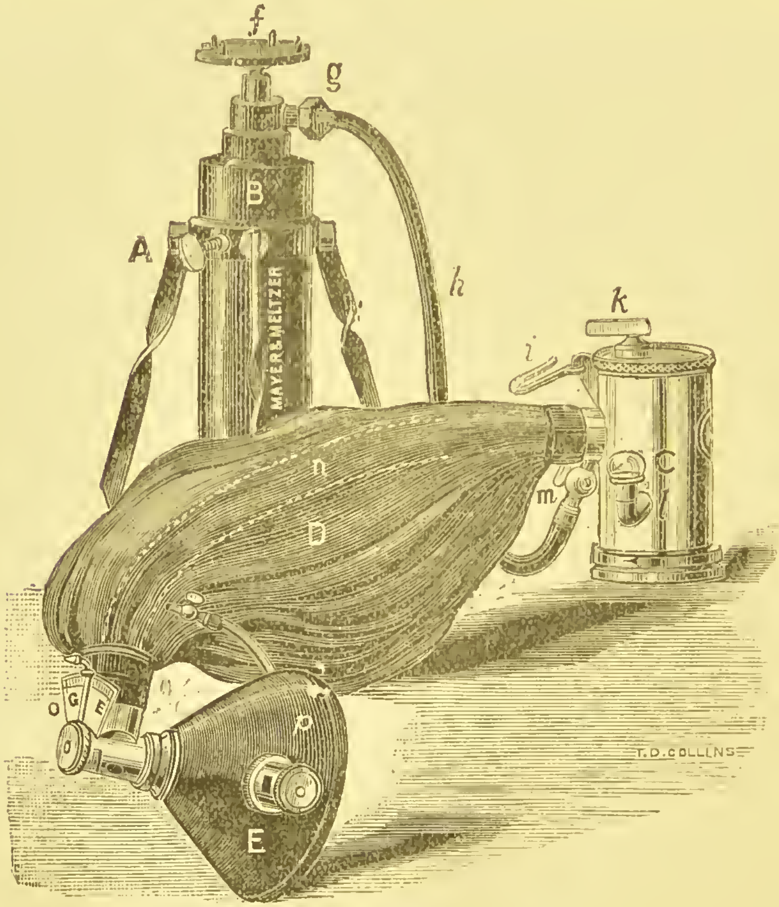

FIG. 36.—Clover's Combined 'Gas-and-Ether' Apparatus.

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[1] This ingenious inhaler is made by Messrs. Mayer & Meltzer, after Clover's own instructions. (For Clover's brief description of it see *Brit. Med. Journ.*, July 15, 1876, p. 74.) I am indebted to Dr. Buxton for the wood-cut.

of A, B, a gas cylinder and stand: C, an ether reservoir, which can be attached to the coat of the administrator by the hook *i*: D, an inhaling bag: E, a face-piece with an expiratory valve in its side, for the escape of expirations when nitrous oxide is being breathed: and O, a regulating stopcock, which determines whether air, gas, or gas mixed with ether shall be breathed by the patient. The regulating stopcock is connected on the one hand to the face-piece, and on the other to the bag (D), and the flexible tube *n* running through the bag. Both D and *n* are attached to the ether reservoir. When the gas cylinder is worked by the foot, gas passes through the tube *h* and the stopcock *m* into the bag (D). The ether reservoir (C) is shown in detail[1] in Fig. 37.

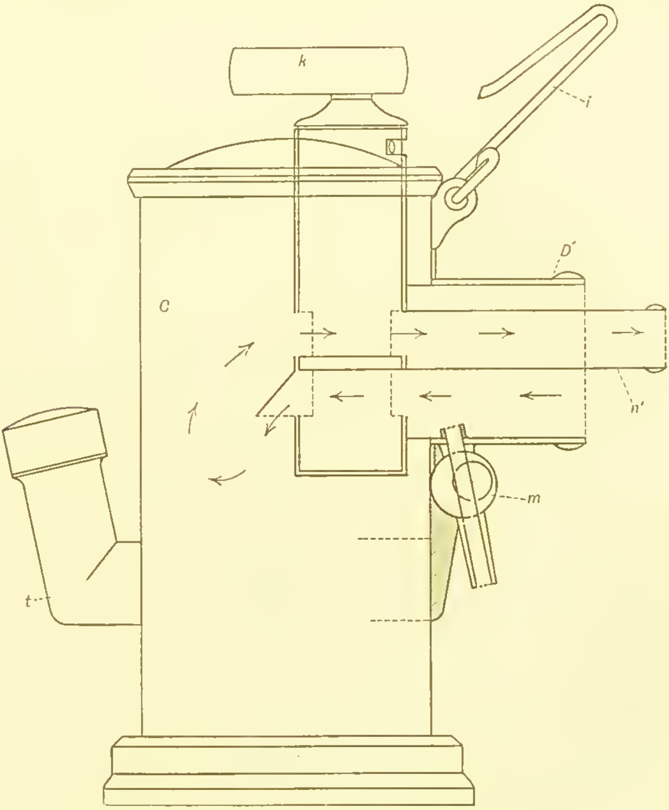

FIG. 37.—Diagrammatic Section of the Ether Reservoir of Clover's Combined Gas-and-Ether Apparatus.

Ether is poured into it by the tube (*t*) at its side (placed diagrammatically opposite to the inhaling-bag attachment). The india-rubber tube (*n*, Fig. 36) is attached to the metal tube (*n'*), and the bag D to D'. There is a small hermetically sealed water-chamber in the base of the reservoir (C). The reservoir has at its upper part a tap (*k*). When *k* is turned, as in the figure, a communication is established (as shown by the arrows) between the gas-bag and the interior of the reservoir.

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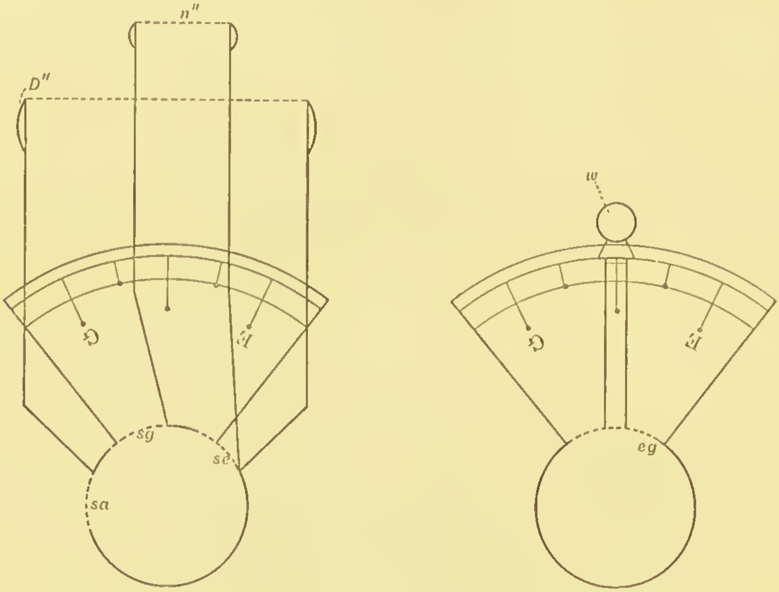
[1] Figs. 37 and 38 are from drawings made by the late Dr. C. E. Sheppard.

When *k* is turned off, all communication between the ether reservoir and the rest of the apparatus is shut off. The regulating stopcock (O), shown in detail in Fig. 38, has a dial-plate with the letters ('G') and ('E'), for gas and ether, engraved upon it. The tube (*n*) and bag (D) of Fig. 36 are attached to *n*″ and D″ of the stopcock. Supposing the tap of the ether reservoir to be turned on, and the inhaling-bag to contain gas, the handle (*w*) when pointing to 'E' on the dial will open up to slot (*se*), and so place the patient in direct communication with the ether reservoir by the flexible india-rubber tube passing through the gas-bag. Or the indicator (*w*) will, when at 'G' on the dial, place the patient in communication with the gas-bag. Or, should the indicator be half way between 'G' and 'E,' both gas and ether will be breathed.



Fixed portion of regulating stopcock (O), with three slots (*sa*, *sg*, and *se*) for air, gas, and ether. Slots shown in dotted line.

Rotating portion of regulating stopcock (O), with one slot (*cg*) shown in dotted line. Handle (*w*) now half way (=half gas and half ether). The fixed dial-plate on which *w* moves is also shown.

FIG. 38.

To use the apparatus the ether reservoir is charged with 4 ozs. of ether, and its tap turned off so that there may be no odour of ether. The bag is then emptied of any air which it may contain. The handle of the regulating stopcock is turned completely off the dial-plate, so that the air-slot is opened. The bag is then filled with nitrous oxide by working the foot-key of the gas cylinder. When the face-piece is applied, air is breathed backwards and forwards through the air-slot. The handle of the regulating stopcock is now placed at 'G,' and nitrous oxide is respired. Expirations escape at the expiratory valve in the side of the face-piece so long as the bag is kept more or less distended by fresh gas. After three or four breaths of gas the tap of the ether reservoir should be turned on. This will open up the way for the gas to pass over ether, but the gas will not *freely* circulate until the handle of the regulating stopcock is moved towards 'E.' This should be done a few seconds later. It is not as a rule necessary to use more than a bag or a bag and a half of gas. When no more is needed the foot-key should be turned off and the supply tube subsequently disconnected from the apparatus. If too much gas be given, the so-called 'stertor' of nitrous oxide narcosis may interfere with the free intake of ether. When the handle of the regulating stopcock is turned towards 'E' the gas current will pass, as shown in Fig. 37. Should much clonic movement occur, a breath of air should be given, either by momentarily opening the air-slot again, or by removing the face-piece for half an inspiration or so of air. As the supply of nitrous oxide to the bag has now ceased, and as the bag has therefore lost all distension, to-and-fro breathing results, because the expiratory valve does not act. Nitrous oxide, ether, and air are thus breathed backwards and forwards. The handle of the regulating stopcock must be passed towards 'E' till a sufficient degree of ether anæsthesia is reached. Stertorous breathing and insensibility of the conjunctiva usually supervene in about two minutes. The administrator should not admit too much fresh air, otherwise his patient will quickly come out of the anæsthesia. By degrees all nitrous oxide will escape from the bag, and the patient will therefore continue to breathe ether and air, without any nitrous oxide, backwards and forwards. After a while the handle of the regulating stopcock may be turned back somewhat, as less ether will be needed; and more air may thenceforward be allowed.

Although this apparatus is intended for the use of nitrous oxide and ether in succession and combination, it may be used for either of these anæsthetics alone. Its drawbacks are: that it is rather cumbrous; that it is complicated; and that it has to be suspended from the coat of the administrator. For administering an anæsthetic to a patient in bed the apparatus is far inferior to others. It nevertheless possesses certain advantages. Thus, it holds sufficient ether for a very long operation: there is no odour of the anæsthetic when the face-piece is applied, as the vapour can be shut off very perfectly: and should any ether remain in it after use it can be kept there ready for a subsequent case. The apparatus is, perhaps, better adapted for dental than for general surgical operations.

B. THE ADMINISTRATION BY MEANS OF AN ORDINARY NITROUS OXIDE APPARATUS AND AN ORMSBY'S ETHER INHALER (MR. WOODHOUSE BRAINE'S METHOD).[1]

The apparatus necessary for administering nitrous oxide and ether by this method has been fully described in the two preceding chapters. Any apparatus which produces deep nitrous oxide anæsthesia will answer well. Mr. Braine employs a long and large silk bag, which holds sufficient gas for the administration, provided that the face-piece has a 'supplemental bag' attached to it (p. 93). The pattern of Ormsby's inhaler preferred by Mr. Braine is that shown in Fig. 35, p. 149, with the exception that it possesses no compartment for a water-chamber, but merely a simple cage for one sponge. Any kind of Ormsby's inhaler will answer, provided that the bag be not too small, and that the face-piece fits well. The sponge should be wrung out in warm water immediately before use. Some administrators keep the Ormsby's inhaler slightly warm up to the moment at which the ether is poured into it, by placing in it a cloth or towel which has been wrung out of very hot water. Something of the kind is certainly of advantage in cold weather, when anæsthetising powerfully built men or alcoholic persons. I have found the little water-chamber shown in Fig. 35 to answer well for the purpose. It may be immersed in warm water before the administration, and introduced into the inhaler just before it is applied to the face of the patient.

It is the object of the administrator, **in giving gas and ether by this method**, to first place the patient fully under nitrous oxide in the usual manner, and then, during the deep anæsthesia thus induced, to introduce into the lungs and circulation, as quickly as possible, a considerable quantity of ether. The method differs from that which has been described above, and from that which will be referred to below, in that there is no *gradual* introduction of ether vapour during *moderate* nitrous oxide anæsthesia. A sudden and strong ether vapour is presented to the patient who has been put deeply under nitrous oxide. The ether may either be added to the Ormsby's inhaler immediately before the inhalation of gas commences, or, should it be desired to prevent the patient detecting any odour of ether in the room, it may be poured upon the sponge after the gas face-piece has been applied. In the case of strong adults, about an ounce and a half of ether should be added to the inhaler. For anæsthetising children and feeble subjects smaller quantities are advisable. Nitrous oxide is administered in the ordinary manner (p. 98) until the usual signs of narcosis manifest themselves. At this point the gas face-piece is removed, and quickly replaced by the Ormsby's inhaler. It is usually said that no air should be admitted during the exchange of inhalers, and, roughly speaking, this is correct. But it is obvious that unless oxygen in some way or another gains access to the lungs, respiration cannot be expected to proceed. Moreover, at the very acme of nitrous oxide anæsthesia the pulse is often quick, small, or even indistinct at the wrist, more especially in feeble patients, and a breath or so of air is needed in order to re-establish the circulation.[1] I have used this method in a very large number of cases, and I find that the quantity of air which should be allowed during the transition is best regulated by the vigour and build of the patient. As a general rule, it is best to remove the gas face-piece during an expiration; to allow half to one inspiration of air; and to apply the Ormsby's inhaler during the following expiration. Some recommend[2] that the Ormsby's inhaler should be applied with the air-slot open, and that after a few moments the slot should be closed. Vigorous subjects require vigorous treatment, and in their case air should be sparingly given. In weakly subjects and in children a full breath, or even two breaths, of air may be allowed, and the ether may be more gradually applied. By placing the Ormsby's inhaler over the face during an expiration, its bag becomes partly distended with expired air, nitrous oxide, and ether. The following inspiration is invariably held for some little while owing to the strength of the ether vapour. Mr. Braine's rule, I believe, is to keep the ether inhaler applied till the patient breathes, unless the conjunctiva should, during the suspended respiration, become insensitive to touch, in which case the inhaler should be removed. If the patient has been placed thoroughly under nitrous oxide, he will not hold his breath so long as if only partial anæsthesia has been induced. A distinct, though brief period of suspended breathing and cyanosis must be looked for in this method, and need not of itself excite alarm. Florid, flabby subjects assume a very cyanotic appearance, but the administrator must not be in too great a hurry to admit air, as otherwise quick recovery may ensue. The first inspiration through the ether sponge is usually a short and ineffectual one, but by degrees respiration grows deeper and more regular. At the approach of stertor a breath of air may be allowed again, and in this way good ether anæsthesia will quickly ensue. Difficulties are most common in patients of alcoholic habits, in those who are fat and flabby, in very muscular subjects with accurately fitting teeth, and in individuals with partial or complete nasal obstruction. When difficulties are, from the appearance of the patient, likely to arise, it is an excellent plan to place a little mouth-prop between the front teeth (Fig. 3, p. 82) before giving the gas.

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[1] *Brit. Med. Journ.*, Dec. 4, 1880. Clover's portable regulating ether inhaler is not as suitable as Ormsby's for administering ether immediately after a full dose of nitrous oxide.

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[1] If the pulse at the wrist be watched at this juncture, unnecessary alarm may be felt by the administrator. The contraction of the muscles of the arm probably helps to explain the almost imperceptible pulse which in some cases is observed. Dr. Russell Reynolds ('Epilepsy,' p. 271) states that the heart may be acting vigorously during an epileptic seizure, but the pulse may be nearly imperceptible at the wrist. A somewhat analogous state is probably induced when gas and ether are administered by this method.

[2] *Brit. Med. Journ.*, Jan. 24, 1885, p. 209.

This plan of administering nitrous oxide and ether has much to recommend it. The apparatus required is simple: all chance of the odour of ether being detected by the patient may be obviated: and when once ether anæsthesia has become established there is no better inhaler than Ormsby's for maintaining narcosis. I have found the method of the greatest value in children, in young adults of both sexes, and in nervous and hysterical women. For anæsthetising very muscular or alcoholic men it has not, in my hands, proved as good as the plan which will next be described. Moreover, it is not a very satisfactory method in dental practice.

C. THE ADMINISTRATION BY MEANS OF A LIMITED QUANTITY OF NITROUS OXIDE, A SPECIAL FORM OF STOPCOCK, AND A CLOVER'S PORTABLE REGULATING ETHER INHALER.

Attempts have from time to time been made to administer nitrous oxide and ether by passing the gas through a Clover's portable ether inhaler. I do not propose to describe in detail what has been done in this direction, as no useful purpose would be served. The chief difficulty which has hitherto presented itself is, that whereas for the successful administration of nitrous oxide the escape of expired gas is essential, at all events at the commencement of the inhalation, no such escape of the expirations is necessary in administering ether, in fact to-and-fro breathing is advisable. Some years ago I devoted a considerable time to this particular matter. I found that by attaching a charged gas-bag to a Clover's inhaler, and by employing a stopcock which would at one moment allow of nitrous oxide being breathed through valves, and would at another (when ether was turned on) permit of to-and-fro breathing, a very satisfactory form of anæsthesia could be obtained.

In addition to a Clover's portable regulating ether inhaler (Fig. 28, p. 139), and a cylinder or pair of cylinders for the supply of nitrous oxide (Fig. 16, p. 92), all that is needed is a gas-bag capable of holding about, but not more than, two gallons of gas, and furnished with the special form of stopcock described in detail on p. 96. This is the same stopcock which I find to give the best results in ordinarily administering nitrous oxide. The ether chamber, which should be slightly warmed in cold weather, or when a very vigorous and muscular patient is about to be anæsthetised, should be charged with an ounce and a half of ether, and its indicator turned to '0.' The gas-bag should be filled or nearly filled with gas, according to the age and strength of the patient. Children will not need more than half a bag full. The bag should be disconnected from the gas supply tube and placed near at hand. A face-piece of appropriate size should be fitted to the ether chamber. It is a good plan for the administrator to apply the face-piece, with the ether chamber attached, to his own face, and to blow out through it, in order to expel any traces of ether vapour present. If this be done, and if care be taken not to unduly warm or shake the apparatus, there will be little if any odour of ether when the face-piece is applied to the patient's face.

The **administration is thus conducted.** If the patient be lying upon his back his head should be turned to one side. The face-piece with the charged ether chamber is then applied during an expiration. Air will be breathed backwards and forwards. When the respiration is seen to be proceeding freely, and the face-piece fits well, the charged gas bag is attached to the ether chamber. Air will still be breathed, but now through the valves of the special stopcock. When the valves are heard to be working properly gas is turned on, and is likewise breathed through the valves. Three or four respirations (or about one-half of the contents of the bag) are allowed to escape. The valve action is now stopped by turning the tap at the upper part of the stopcock. At the same moment at which the patient begins to breathe gas backwards and forwards, the rotation of the ether chamber, for the addition of ether vapour, should be commenced. Rotation may be effected more quickly than when the ether chamber is used without gas. The administrator will, in fact, find that he can, in a few seconds from the commencement of the administration, rotate the ether chamber as far as '1' or '1½' (Fig. 39). Should swallowing or coughing arise, he must rotate more slowly. Respiration soon becomes deep and regular, and more and more ether may be admitted. At about this juncture, if the apparatus has been fitting the face well, signs of nitrous oxide narcosis may appear, especially in those who are quickly affected by this gas. Should jerky breathing or 'jactitation' arise, one full inspiration of air should be admitted at the air-tap. It should be remembered, however, that in giving gas and ether by this method, the object is to just steer clear of the clonus and 'stertor' of nitrous oxide narcosis, and to gradually but increasingly mix ether with the gas. In muscular and vigorous subjects, the quantity of gas above mentioned will be found to be, as a general rule, insufficient to lead to the usual signs of deep nitrous oxide anæsthesia. The rotation of the ether chamber should be continued till the indicator points to '2,' '3,' or 'F.' The mistake that is most commonly made is that air is admitted too soon. Should air be given during the first minute or so, the patient will partially come round, hold his breath, set his teeth, and give a good deal of trouble. Duskiness of the features must be expected. Speaking generally, air should not be allowed till the patient is stertorous, when one breath may be given. In this manner the patient will continue breathing a mixture of nitrous oxide, ether, and air, till the usual signs of deep ether anæsthesia appear, when the gas-bag may be detached, and the little bag ordinarily used with Clover's inhaler may be substituted. This will necessarily admit more air, and the dusky colour of the features will hence become less pronounced. The administration should then be conducted as described on p. 146.

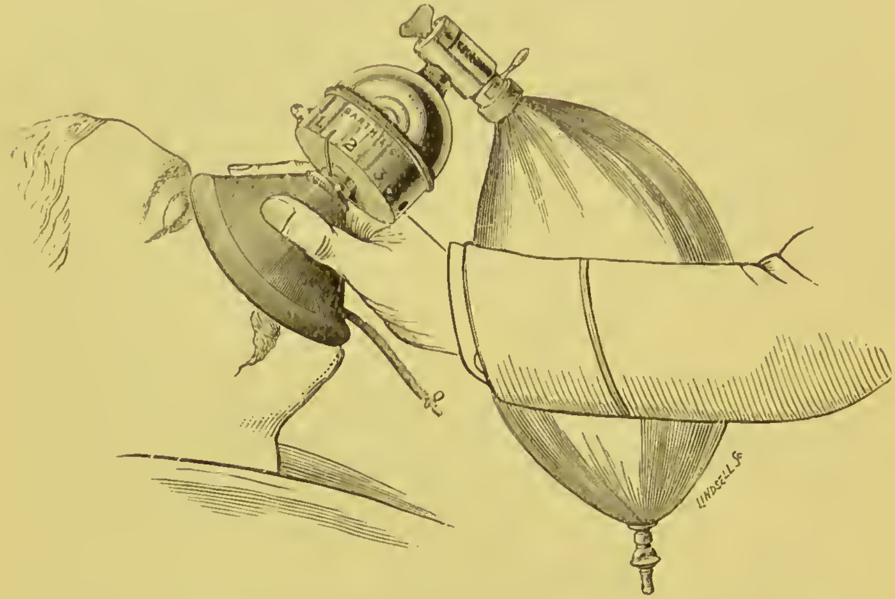

FIG. 39.—The Administration of Nitrous Oxide and Ether by means of a Clover's Portable Ether Inhaler, a special form of Stopcock, and a detached Gas-Bag.

In **dental practice** an available anæsthesia somewhat longer than that obtainable from nitrous oxide alone is often desired; and this particular method is the best for the purpose. Should the operator wish for an anæsthesia of one minute after the apparatus is withdrawn from the face, this period may usually be depended upon after an inhalation, as above directed, for one and a half or two minutes. After a little practice the administrator will be able to estimate with tolerable certainty the length of inhalation needed to secure the proper length of anæsthesia. When only a short anæsthesia is wanted (1 to 1½ min.), some form of mouth-prop should be inserted between the teeth or gums before the face-piece is applied; but if profound surgical anæsthesia, for the extraction of numerous difficult teeth, be required, I find it far better not to use any form of prop, as otherwise free breathing may be interfered with (see p. 45).

This plan of giving nitrous oxide and ether has numerous advantages. In the first place, only a limited quantity of nitrous oxide is needed, so that the bag may be filled before the patient enters the room, or it may be filled outside the room and carried in. The patient is thus spared the noise, &c., connected with the supply of gas to the gas-bag, and the administrator is spared the trouble of keeping up a supply of the gas with the foot-key during the administration. The patient need never see the gas-bag. When the face-piece and ether chamber are applied, he should be told to close his eyes, and the gas-bag may then be adapted. One frequently has to give gas and ether to patients who are lying in bed, and under these circumstances it is a great convenience to have at hand a detached bag of gas containing sufficient, when used as directed, for any patient. Some have objected to the method on the ground that there is always a smell of ether in the apparatus when it is first applied to the face. But, by proceeding as above narrated, the odour will either be so slight that it matters but little, or will not be detected at all. I have tried all methods of giving gas and ether, and I find this to be the best for general use.

CHAPTER IV.

CHLOROFORM.

A. APPARATUS AND METHODS OF ADMINISTRATION.

SIR JAMES SIMPSON, to whom we are indebted for the introduction of chloroform as an anæsthetic, first administered the drug by means of a simple handkerchief arranged in a cup-like form. An unmeasured quantity of chloroform, usually about a drachm, was poured into the hollow thus formed, and the handkerchief applied to the patient's face. He recommended that the vapour should be exhibited "powerfully and speedily," to use his own words,[1] and considered a gradual administration objectionable, owing to the frequent occurrence of inconvenient excitement. Subsequently he used a folded cloth or towel, and he continued to adopt this mode of administration for several years. In 1860, however, he again modified his procedure, apparently in consequence of recognising the necessity of providing for a more free admixture of air with the chloroform vapour than that which usually resulted from the employment of the folded towel. He now advised that a *single* layer of a towel or handkerchief should be laid over the patient's nose and mouth, and that the anæsthetic should be added drop by drop. From the time of Simpson to the present day chloroform has been the anæsthetic, *par excellence*, throughout Scotland; and although there are many Scotch surgeons who still give the anæsthetic "powerfully and speedily," there are many others who follow the later teaching of Simpson, and use smaller quantities frequently applied.[2]

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[1] 'The Works of Sir James Y. Simpson, Bart.,' vol. ii., Edinburgh, 1871, p. 177.

[2] My friend Dr. Cockburn Smith, who has lately visited the great surgical centres of Scotland, with the object of observing the methods of chloroform administration in use, informs me that there are two chief ways in which the agent is exhibited. In one of these it is liberally added from time to time to a folded towel (sometimes arranged as an open cone), and the administration is quickly conducted. In the other the agent is given in small quantities at a time, usually from a drop-bottle, and the inhalation is slowly and cautiously conducted by means of an Esmarch's mask, or the corner of a towel drawn

In 1847, the year in which Simpson drew attention to the anæsthetic properties of chloroform, Snow devised an inhaler, which he subsequently perfected and used with success in several thousand cases. His object was to present to the patient an atmosphere containing a known percentage of chloroform vapour, for he had found, by numerous experiments on animals, that concentrated atmospheres, such as those which might result from the use of a folded towel, were highly dangerous to life.

Snow's inhaler consisted of a double metal cylinder, the outer space containing water, and the inner one serving for the evaporation of chloroform from bibulous paper arranged in coils. The inner cylinder, which had holes at its upper part for the free admission of air, communicated by means of a flexible india-rubber tube with a face-piece containing inspiratory and expiratory valves. Dr. Francis Sibson was apparently the first to employ a face-piece to cover both the nose and mouth. His face-piece was made of sheet lead, in order that it might be easily adapted to any face. Dr. Snow added valves. Snow's inhaler was contrived to supply, at about 60° F., and in the ordinary process of inhalation, about 5 per cent. of chloroform vapour. The expiratory valve to the face-piece was so arranged, however, that a much more dilute vapour could be employed. Two to two and a half fluid drachms of chloroform were introduced into the inhaler, and one drachm at a time subsequently added.

In 1849 Snow employed, in a few cases, a bag of known capacity, which could be inflated by bellows, and in this bag a measured quantity of chloroform was placed. He so regulated the proportions that an atmosphere containing 4 per cent. of vapour resulted. He found this plan of administration, however, somewhat inconvenient, and preferred the inhaler previously described, although he recognised the fact that greater accuracy was obtainable by using a bag of known capacity.

Snow found that far more uniform effects were obtained by means of his inhaler than by simply pouring various quantities of the anæsthetic on a cloth or towel, and he strongly condemned the latter procedure.[1]

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through a safety-pin. Dr. Smith has had exceptional opportunities of comparing the two plans, and has sent me interesting notes from time to time of the observations he has made. He has repeatedly noticed in the latter or slow method a very quick pulse, hurried breathing, and some cyanosis, this condition alternating with tranquil, almost imperceptible breathing, a slow, feeble pulse, and loss of colour. With these phenomena the conjunctival reflex is usually present; but the signs referred to are generally regarded as indications for arresting the administration. In the more rapid method (chloroform being given much more freely) he has observed, that the conjunctival reflex is usually absent, the pupils small (about 2½ mm.), and inactive to light, the breathing more regular and deeper, and the colour and pulse better than in slower and more cautious plans of procedure.

[1] For further particulars see 'On Chloroform and other Anæsthetics,' by John Snow, M.D., 1858, p. 82.

Clover agreed with Snow as to the advantages of working with a known percentage of vapour, and for many years successfully administered chloroform upon these lines.

Clover's chloroform apparatus[1] consisted of a bag holding 8000 cubic inches of air, and connected by a flexible tube to a face-piece. The bag was charged before use by means of a bellows holding 1000 cubic inches. On its way from the bellows to the bag the air was made to pass through a warm chamber containing chloroform. Thirty to forty minims of chloroform were added to this chamber, by a graduated syringe, for every thousand cubic inches of air pumped through. This would give from 3½ to 4½ per cent. of chloroform vapour. The face-piece and tube of the apparatus were almost identical with those used by Snow.

Experience has shown that even with the most carefully devised apparatus it is impossible always to avoid accidents. The inhalers of Snow and Clover were constructed and arranged for the supply to the patient of an atmosphere containing not more than 5 per cent. of chloroform vapour. Although the results obtained by these observers were in the highest degree satisfactory, it is doubtful whether we are justified in assuming that their success was chiefly attributable to the apparatus they employed.[2] Similar success in the use of chloroform has been met with by those who, following the teaching of Simpson and Syme, have never used any form of inhaler, but have exhibited the anæsthetic by means of a simple cloth or towel.

Sir Joseph Lister has devoted much attention to the administration of chloroform. Writing in 1861 he recommended: that a common towel, as suggested by Sir James Simpson, should be so folded as to make a square of six layers: that an unmeasured quantity of chloroform, sufficient to moisten a surface the size of the palm of the hand, should be poured upon the towel: that the latter should be brought as close to the nose and mouth of the patient as could be comfortably borne: and that more chloroform should be added from time to time. As Snow had drawn attention to the danger of too concentrated a chloroform vapour, and had from numerous experiments fixed the maximum proportion of chloroform vapour which should be inhaled at 5 per cent., Sir J. Lister was led to experimentally estimate the percentage of vapour given off from the under surface of a cloth moistened with $1\frac{1}{2}$ drachms of chloroform, and placed immediately above the face. Snow had stated that as much as 9.5 per cent. of chloroform vapour might be inhaled from a cloth at 70° F.; but Sir J. Lister's observations led him to state that the percentage of chloroform vapour breathed from a moistened cloth held close to the face was below 4.5 per cent., and therefore distinctly below the percentage employed by Dr. Snow in his inhaler. Dr. Sansom, writing in 1870,[1] supported Dr. Snow in his contentions, and after making experiments, urged that it was possible for a patient, at a temperature from 60°–64° F., to inhale an atmosphere containing more than 13 per cent. of chloroform vapour, although but one drachm of the anæsthetic had been sprinkled upon lint. When we consider the numerous circumstances which may influence the percentage of vapour inhaled from a cloth moistened with chloroform, we cannot help receiving with some hesitation any statements made as to the percentage breathed in actual practice. This is indeed the weak point in the administration of chloroform from a folded towel. It is true that the risk of too concentrated a vapour may be greatly reduced by providing for the free access of air; but should this precaution be not continuously borne in mind, difficulties may arise. As Sir J. Lister has pointed out, a large surface moistened with chloroform, such as that which may be presented to the patient when employing a folded towel, handkerchief, or large piece of lint, will supply a much higher percentage of chloroform in the inspired air than a smaller surface. This consideration seems to have led Sir J. Lister, of late years, to use the corner of a towel drawn through a safety-pin (Fig. 42, p. 191), or otherwise constricted at a point a few inches from the corner itself, in preference to a folded towel or piece of lint. By using the corner of a towel in this way, a concave mask, suitable to the size of the patient, is formed, and the anæsthetic is added in small, but not too small quantities at a time. In this way the greater part of the mask becomes saturated, and the moist condition is maintained till anæsthesia is produced. The little mask or cap should extend from the root of the nose to the point of the chin. This is the plan of administration which Sir J. Lister now employs. It differs in no material point from that in which a Skinner's or Esmarch's mask of open shape is used. From calculations which Sir J. Lister has made, he estimates the volume-percentage of chloroform inhaled to be about 1.2—a smaller percentage of chloroform vapour than that which he calculated was inhaled when he adopted the folded cloth for administering the anæsthetic.

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[1] Described in Erichsen's 'Science and Art of Surgery,' vol. i. 1877, p. 18.

[2] Of 101 chloroform fatalities collected by Kappeler 9 occurred with complicated inhalers. Of these 9 deaths 5 took place during the use of Clover's apparatus. Of the 109 fatalities collected by the English Chloroform Committee 28 took place with inhalers, and in 5 of these 28 cases Snow's apparatus was being used.

Taking everything into consideration we may say, I think, that chloroform is best administered either by means of a Skinner's mask, a piece of lint, or the corner of a towel drawn through a safety-pin. There is very little difference in these plans.

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[1] *Med. Times and Gaz.,* vol. i. 1870, p. 436.

Skinner's mask (Fig. 40) has the advantage of retaining its shape somewhat better than a mask made from lint or towel. It should be covered with a single layer[1] of domett, and should have a *wide* opening

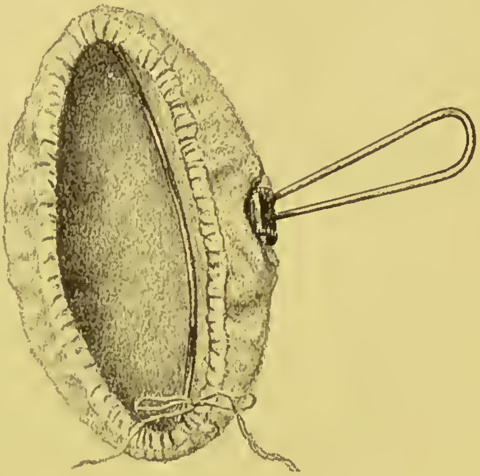

FIG. 40.—Skinner's Mask.

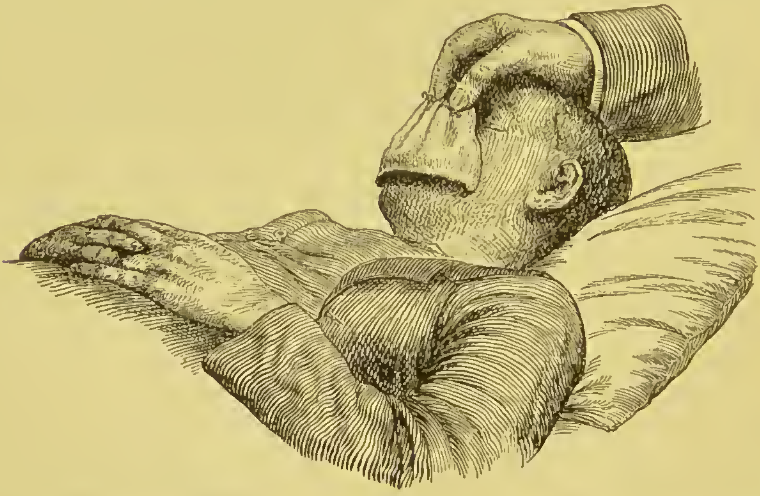

FIG. 41.—Piece of Lint pinned up to form a Mask for the Administration of Chloroform. From a photograph.

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[1] Dr. Stanley Tresidder, of New South Wales, has informed me that he finds it impossible to anæsthetise patients with a Skinner's mask having *one* layer of flannel. This is probably due to the higher temperature of the climate. The average summer temperature is about 90° F. He finds it necessary to have *two* layers of thick flannel on the Skinner's mask.

for the nose and mouth, in order to permit plenty of air to gain access to the patient.

If **lint** be used, the best plan is to take a piece 11 inches long and 7 inches wide, to fold it once over so that the double layer measures 7 inches by 5½, to pinch up between the fingers the free double edge opposite to the folded edge, and to run a safety-pin through the pinched up portion so that a concave and fan-shaped mask is formed (Fig. 41).

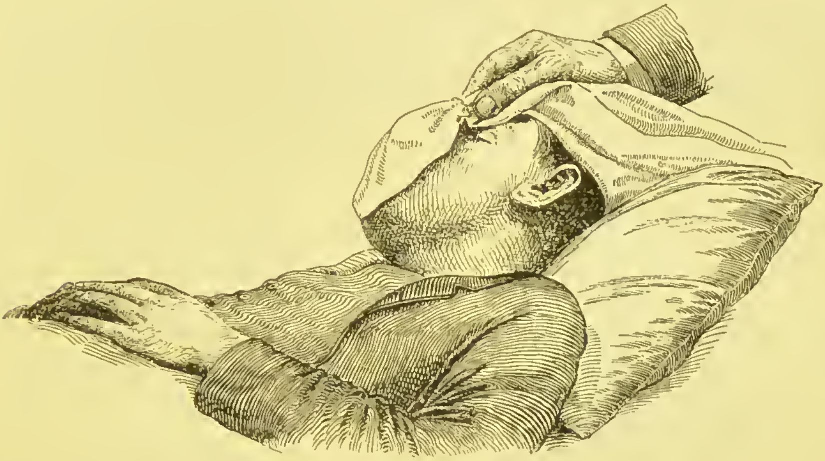

FIG. 42.—Corner of Towel drawn through a Safety-pin. From a photograph.

The **corner of a towel** drawn through a safety-pin, as recommended by Sir Joseph Lister, also makes an excellent little mask (Fig. 42).

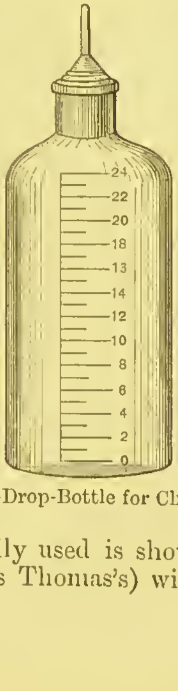

FIG. 43.—Drop-Bottle for Chloroform.

The **drop-bottle** ordinarily used is shown in Fig. 43. That represented in Fig. 44 (known as Thomas's) will be found to be very convenient in practice.[1] It has a capacity of 2 ozs., and is graduated from above downwards. There is a spring valve stopper which is worked by the forefinger of the administrator. By a very simple contrivance this spring valve or stopper may be arranged in either of three positions. It may be arranged (*a*) so that no chloroform whatever escapes, even though pressure be made on the button, or the bottle be turned upside down; (*b*) so that chloroform escapes, but only during the time that the button is being pressed down; or (*c*), so that, by simply turning the bottle upside down, chloroform flows out in a steady and small, but not a fitful stream, no pressure upon the button being necessary. The first position is the proper one when the bottle is not in use. The third position will be found very convenient during the continuous administration of chloroform. The bottle may be placed vertically in the waistcoat pocket, and all that is necessary is to remove it and turn it up for a moment, when the chloroform will readily escape without any jerkiness whatever, and without any pressure on the button being made.

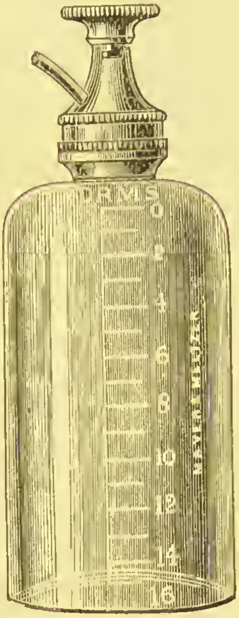

Fig. 44.—Thomas's Drop-bottle.

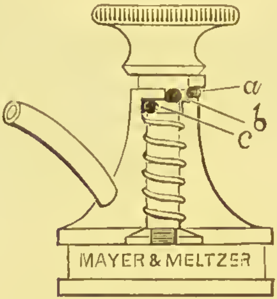

Fig. 45.—Section of Spring Stopper of Thomas's Drop-bottle, showing the three positions in which the stopper may be arranged.

In using the drop-bottle and one of the masks above recommended, we should, in the first place, present to the patient a very diluted vapour. We have good evidence that the heroic plan already discussed is not unattended by risk. But we must not lose sight of the fact that a too sparing use of the drug is also open to objection. A few drops should be first administered in order not to alarm the patient by any suffocative sensations.

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[1] This drop-bottle is made by Messrs. Mayer & Meltzer. The additional slot (Fig. 45, *c*) was suggested by Dr. Sheppard.

The mask should be gradually brought nearer and nearer to the face. More of the anæsthetic should now be given, so that a distinctly moistened surface results. Any holding of the breath or coughing should be met by a partial withdrawal of the mask. The inhalation should, however, not be wholly discontinued. An endeavour should, in fact, be made to continuously give a well-diluted vapour. The administrator should steer between the two extremes, the rapid and the slow plans of administration. In patients requiring large quantities of the anæsthetic, it may be necessary to keep the mask quite moist, at all events for the major portion of the administration. I have found that by using the Skinner's mask and drop-bottle described, an average of about $1\frac{1}{2}$ or 2 ozs. of chloroform per hour is consumed by adult subjects, *i.e.*, about 1 drachm or a trifle more every five minutes. Children and weakly patients require less than this; whilst in the case of alcoholic persons, &c., more will be needed. The average given is that for the first hour. Less will be required for the second, and less again for the third hour, should the operation be of this duration.

Dr. Kirk[1] has drawn attention to the bad practice of wholly withdrawing chloroform after once the administration has been started, *i.e.*, of administering it in an intermittent fashion; and he attributes many of the chloroform fatalities which have been recorded to this error. He puts forward a theory to explain the clinical phenomena which he has observed. He believes that the withdrawal of chloroform during partial anæsthesia leads to a 'rebound' of the circulation which terminates in syncope; but the facts upon which he bases his views are so meagre that we are hardly justified in arguing from them. Moreover, the fatal cases which he has selected to support his theory are, to my mind, capable of being equally well explained on more probable grounds, *e.g.*, reflex shock from the operation during imperfect anæsthesia, syncope during vomiting, &c. An intermittent and sparing administration of chloroform is undoubtedly objectionable, and possibly dangerous in some cases. When chloroform is given in very small doses, swallowing, holding the breath, and exhaustion from struggling, coughing, and vomiting are all liable to arise, and the asphyxiated state thus induced may, as we know, prove a source of danger. All such phenomena are avoided by a more liberal use of the drug.

Chloroform may be administered to children during sleep.[2]

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[1] 'A New Theory of Chloroform Syncope,' by Dr. R. Kirk. See also a review of the book in the *Brit. Med. Journ.*, March 21, 1891, p. 649.

[2] See *Lancet*, vol. ii. 1872, pp. 514, 549. See also a letter from Dr. John G. Marshall in *Lancet*, April 24, 1886.

I have only once adopted this course, but the result was very satisfactory. The little child, a sufferer from enlarged tonsils, was asleep in its bed and breathing noisily. I added a drop or two of chloroform at a time to a Skinner's mask at some distance from the face. An occasional act of deglutition occurred, altering the rhythm of breathing, but this passed off, and without any movement whatever, the corneæ soon became insensitive. The operation was then performed; and the child slept for some hours after.

Numerous other inhalers besides those already referred to have been devised; but space will not permit of reference to them. Most of them have one serious objection, viz., that they possess a face-piece intended to accurately fit the face of the patient. There is, however, one inhaler to which reference must be made —that of Dr. Junker. This ingenious apparatus is of special use in the surgery of the mouth and nose; for chloroform vapour may be pumped through a narrow tube into the buccal or nasal cavities, and anæsthesia thus be satisfactorily maintained.

Junker's inhaler was originally intended by its inventor for the administration of 'bichloride of methylene.' The principle of the apparatus is simple. Air is pumped by means of a hand-bellows and tubes through chloroform, and the air, carrying with it a varying quantity of vapour, is transmitted to a loosely fitting face-piece. Fig. 46 shows the original pattern of the inhaler.[1] The bottle for the chloroform is graduated to hold from 1 to 8 drachms, and having been charged with somewhat less than the latter quantity, is suspended by a little hook from the coat of the administrator. Air is pumped through the anæsthetic by means of the hand-bellows, an india-rubber tube, and a *long* metal tube passing

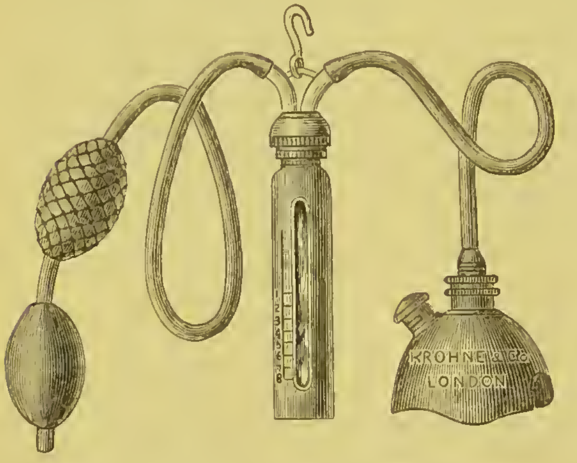

FIG. 46.—Junker's Apparatus: original pattern.

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[1] Although Junker's apparatus when carefully used probably lessens the risk of chloroform narcosis, several deaths have occurred in connection with its employment. It is not a suitable inhaler for infants or young children, unless the chloroform be considerably diluted with alcohol. For an account of fatal cases see *Brit. Med. Journ.*, Sept. 29, 1888, p. 719; Sept. 15, 1888, p. 625; Dec. 21, 1889, p. 140; July 31, 1889, p. 88; June 10, 1882, p. 889.

to the bottom of the chloroform bottle. The metal tube is only partly seen in the drawing. The air, laden with chloroform vapour, escapes from the bottle by a *short* metal tube at its upper part, connected with an india-rubber tube terminating in a face-piece. The india-rubber tube leading from the bellows to the bottle may be termed the afferent or bellows-tube ; that leading from the bottle to the face-piece may be termed the efferent or face-piece tube. The face-piece is usually made of vulcanite or leather ; but latterly a kind of Skinner's mask, shaped to the face, has been introduced, and I believe answers well. Vulcanite and leather face-pieces should not be furnished with air-cushions, as they are not intended to fit the face accurately. Whatever form of face-piece is used, it is important, in the event of it adapting itself more or less closely to the features, that fresh air should enter and expired air escape, with the utmost freedom. When it is desired to keep up chloroform anæsthesia without employing a face-piece, as in certain mouth and nose operations, the face-piece may be disconnected, and the efferent tube, usually terminating in a bent metal mount similar to that shown in Fig. 49, p. 199, may be passed into the buccal or nasal cavity, or it may be connected to the Mason's gag shown in Fig. 50, p. 199. When the hand-bellows is worked, air will be heard to bubble up through the chloroform. It is important, in using the inhaler, to see that the afferent and efferent tubes are attached to the right metal tubes of the bottle. It is also important not to have more than 5 or 6 drachms of chloroform in the bottle, otherwise some of the liquid may possibly gain access to the efferent tube. And, lastly, care should be taken lest the bottle containing the chloroform becomes tilted during the administration.

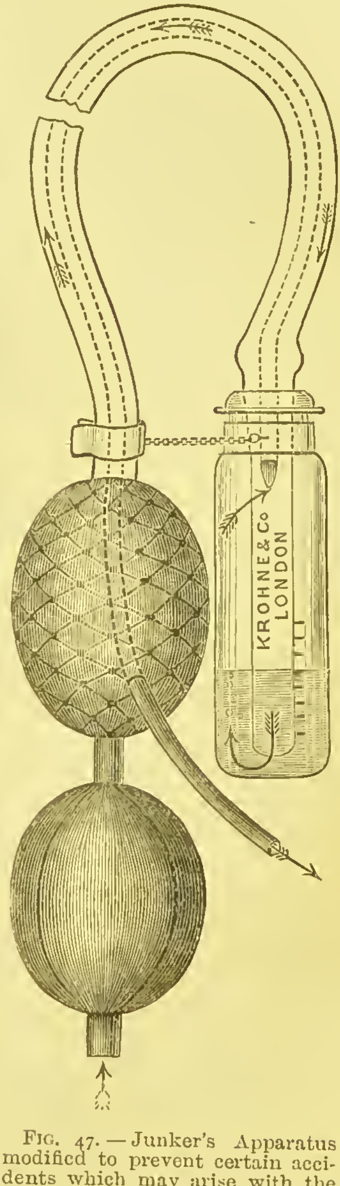

Fig. 47. — Junker's Apparatus modified to prevent certain accidents which may arise with the ordinary inhaler.

It has, on more than one occasion, happened that, by an oversight, the india-rubber tubes have been adapted to the wrong metal tubes of the bottle containing the chloroform. The result has been that the liquid chloroform has been pumped into the face-piece, and in some cases into the nose or mouth of the patient.[1] A somewhat similar accident has also been known to occur by the chloroform bottle becoming tilted during the administration. As one or two fatalities have arisen from these accidents I thought it worth while to modify the inhaler with the object, not only of preventing the possibility of the tubes being wrongly adjusted, but of rendering the bottle less likely to become tilted during use. Fig. 47 shows this modification. Air enters as usual through the hand-bellows. The afferent india-rubber tube is made much larger than that ordinarily used, and the same may be said of the long metal tube of the bottle with which it becomes continuous. The efferent system commences in the wall of this long metal tube at the little orifice shown. From this orifice the efferent tube passes through the larger afferent one, and emerges at the hand-bellows. Arrows show the direction of the currents. The air entering the bellows passes along in the afferent tube system and bubbles up, as shown, through the chloroform. It then escapes by the efferent system. The apparatus is conveniently worked, as represented in Fig. 48. By this modification

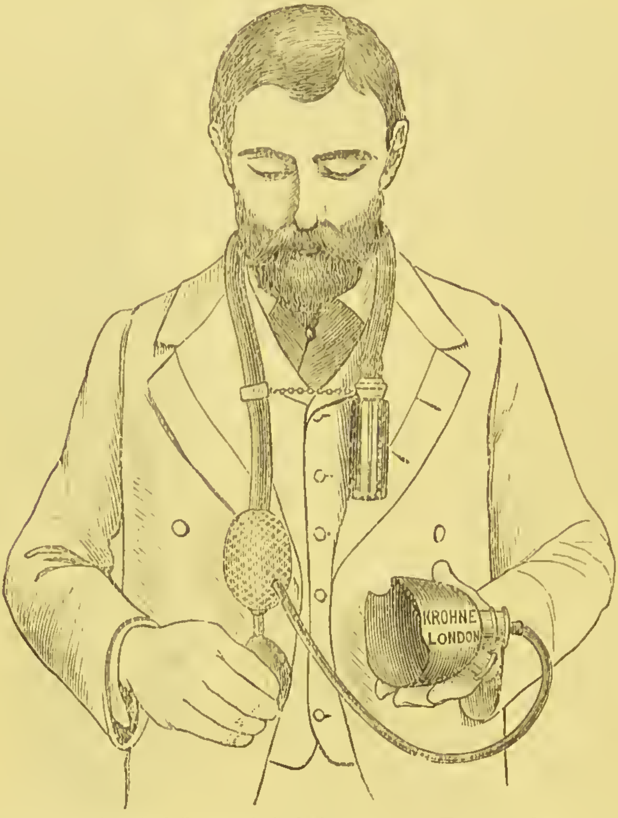

FIG. 48.—Modified Junker's Inhaler in use. From a photograph.

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[1] Death has resulted in more than one case. On one occasion tracheotomy became necessary in order to restore respiration after liquid chloroform had thus gained entrance to the upper air-passages.

in Junker's apparatus there is no possibility of the flexible tubes being interchanged; and as a kind of collar is formed by the little chain shown, there is no likelihood of the bottle becoming tilted during the administration.

Other modifications have been made in this inhaler. In addition to the replacement of the vulcanite face-piece by the flannel mask, Messrs. Krohne & Sesemann have interposed in the afferent rubber tube a little stopcock; and when this is nearly closed it offers such obstruction to the bellows that a more or less equable chloroform vapour is continuously transmitted. These makers have also added a feather to the vulcanite face-piece, so that the respiration of the patient may be observed. Dr. Dudley Buxton has[1] replaced the hand-bellows by a foot-bellows, and has added a little funnel-shaped filling tube to the top of the bottle, so that chloroform may be introduced during an administration without any unscrewing. Mr. Carter Braine has devised a bottle which admits of being placed in any position without the chance of chloroform gaining access to the efferent tubes.[2]

It is practically impossible to say what percentage of chloroform vapour is usually inhaled from the mask of Junker's apparatus. The percentage will depend upon a variety of circumstances. Foremost among these must be mentioned the quantity of air taken in with each inspiration. All kinds of breathing are met with during chloroformisation, from the deep regular respiration of the broad-chested and stalwart patient, to the feeble and almost imperceptible breathing of the ill-developed and fragile individual. Moreover, respiration may vary in amplitude from time to time in the same patient, even though the same level of anæsthesia be maintained. The next most important factor is probably the manner in which the face-piece fits, or the degree to which air gains admission through it when it is adapted accurately to the features. Then we must take into account the temperature of the chloroform at the time; and this will greatly depend upon the rapidity with which the air is forced through the liquid. Professor Zengerle of Constanz has conducted, at Kappeler's request, some interesting experiments on this point.[3] I reproduce his figures.

Experiment.	Compressions of Bellows per Minute.	Quantity of Air Supplied.	Chloroform Evaporated.
1	120	4 litres	.7 gm.
2	60	2.2 ,,	1.2 ,,
3	40	1.6 ,,	1.4 ,,
4	30	1.2 ,,	1.5 ,,
5	24	1.0 ,,	1.6 ,,
6	20	.9 ,,	1.7 ,,
7	17	.8 ,,	1.7 ,,
8	15	.7 ,,	1.7 ,,

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[1] *Op. cit.*, p. 113.

[2] *Brit. Med. Journ.*, June 25, 1892, p. 1364.

[3] Kappeler's 'Anæsthetica.'

The temperature of the chloroform used was 63°.5 F. From these experiments it is concluded that *the speed of pumping is in inverse ratio to the percentage of chloroform in the issuing air*—a point of some importance in practice. Lastly, the temperature of the room will also exert a slight influence. But, although the percentage of chloroform vapour inhaled must vary very widely according to the circumstances mentioned, it may not be out of place to venture upon the following rough calculation, in order to obtain an idea of the percentage of vapour inhaled under certain of the above circumstances. Given that the respiration of the patient, so far as the free access of air is concerned, is unimpeded; that he breathes at the rate of 24 per minute; that he inhales 540 cubic inches of air per minute (Lister); that the bellows of the inhaler is compressed only during each inspiration, so that all the chloroform vapour is inspired; and that 1 grain of chloroform produces .767 cubic inches of vapour at 60° F. (Snow); then, applying Zengerle's table, an atmosphere of 3.5 per cent. of chloroform vapour will be breathed by the patient. In this calculation it is taken for granted that all the chloroform evaporated by each pump of the bellows is inhaled. Should the face-piece fit loosely, some would escape, and the same would occur if the pumping were not accurately timed with inspiration. Under these latter circumstances, the percentage of vapour inhaled would be less than 3.5. On the other hand, should the breathing be shallow, and not more than 200 cubic inches of air be inspired per minute, a considerably higher, and possibly a dangerous percentage of vapour would result.

In using Junker's inhaler the administrator must first see that it is in good working order; he should invariably test it before he commences the administration. Having satisfied himself that it works properly, he should at first hold the face-piece at some little distance from the face, and should gently compress the bellows. He will soon see whether his patient can breathe without discomfort the vapour he thus presents to him. The bellows should be compressed during the inspiratory phase of breathing. Gradually the face-piece should be brought closer to the face. By avoiding jerkiness in pumping, and by more or less rhythmically compressing the bellows, a tolerably constant chloroform atmosphere may be maintained. Rapid pumping, as above pointed out, is open to objection. When more chloroform seems indicated, the face-piece should be more continuously or more closely applied; when less is required, the face-piece should be removed for longer periods, or should be only lightly kept over the face.

Junker's apparatus is very useful in operations within or about the mouth, nose, or pharynx. As already mentioned (p. 34), it is best in these cases to first secure deep ether anæsthesia, and then to continue with Junker's inhaler when the patient commences to emerge from the ether narcosis. Should the administrator decide on this course, he should give the chloroform vapour, through the mouth or nose, by means of a metal tube or silk catheter attached to the efferent rubber tube of the inhaler. I find a silk catheter of great use for passing through the nostril to the back of the pharynx. When a mouth-tube is used, that shown in Fig. 49 will be found useful. It is made of hard metal, and is of large bore. Tubes made of soft metal, especially if of small bore, are liable to become so bent that obstruction results. When the mouth is to be used for the introduction of the vapour, I find the arrangement shown in Fig. 50, made for me by Messrs. Krohne & Sesemann, to be very convenient. Bent metal tubes are brazed to the arms of an ordinary Mason's gag, and to one of these tubes the india-rubber piping of Junker's apparatus is attached.[1] The chloroform vapour is thus transmitted to the

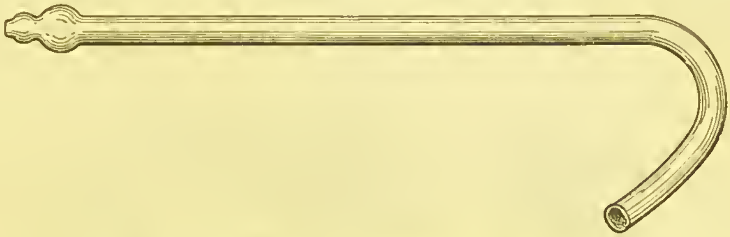

FIG. 49.—Bent Metal Mouth-Tube, for transmission of chloroform vapour from Junker's Inhaler. (Half-size.)

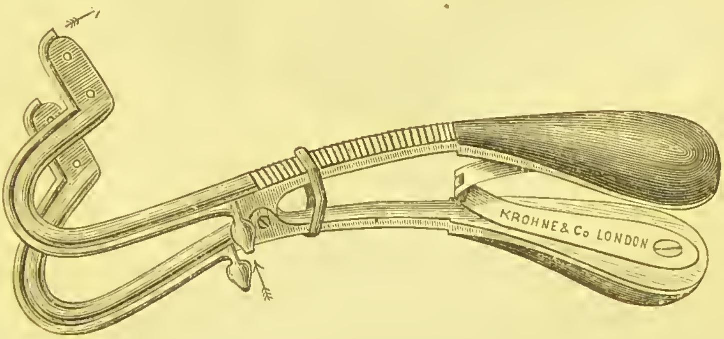

FIG. 50.—Mason's Gag furnished with Metal Tubes for transmission of chloroform vapour to back of mouth.

[1] I described this arrangement in the *Lancet* of Jan. 10, 1891, p. 81: 'Remarks on the Administration of Anæsthetics in Oral and Nasal Surgery.'

back of the throat along the arms of the gag, as represented in Fig. 51. It is necessary to remember in using this arrangement that unless the gag be adjusted far back in the mouth the chloroform vapour may not reach the larynx in sufficient strength to keep up good anæsthesia, more especially in patients requiring much chloroform. In those cases in which the surgeon wishes the patient's head to be turned completely upon its side in order that he may operate upon the cheek or jaw thus rendered easily available, some difficulty in keeping a gag in position may be met with. It is obvious, in the first place, that some form of gag is necessary; and, in the second place, that the gag should be upon that side of the mouth which is lying against the pillow. A Mason's gag almost invariably becomes dislodged in these cases by reason of its arms resting upon the pillow. I have found the gag of Fig. 52 (made for me by Messrs. Weiss & Son) to be useful on these occasions. It should be inserted between the canine or first bicuspid teeth on that side which is to lie upon the pillow. By rotating the wheel at the end, the mouth can be opened to any desired extent, and a mouth or nose tube used to keep up

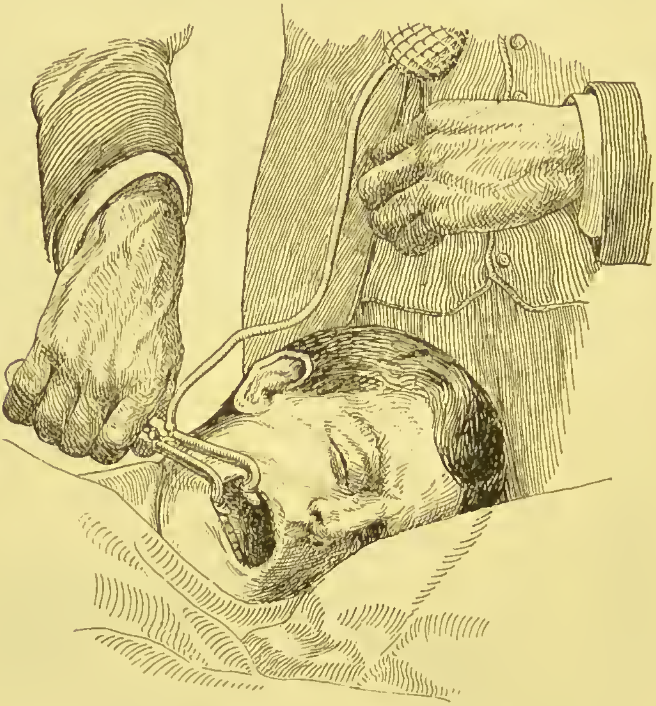

FIG. 51.—Gag of Fig. 50 in position. From a photograph.

anæsthesia. In the removal of the upper jaw, and more especially in operations upon the antrum, this arrangement answers well.

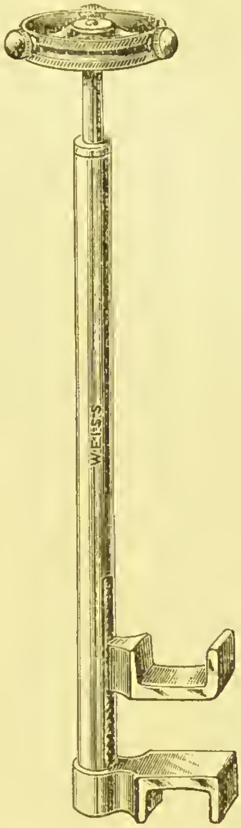

FIG. 52.—Screw-Gag for use in certain nose and mouth operations.

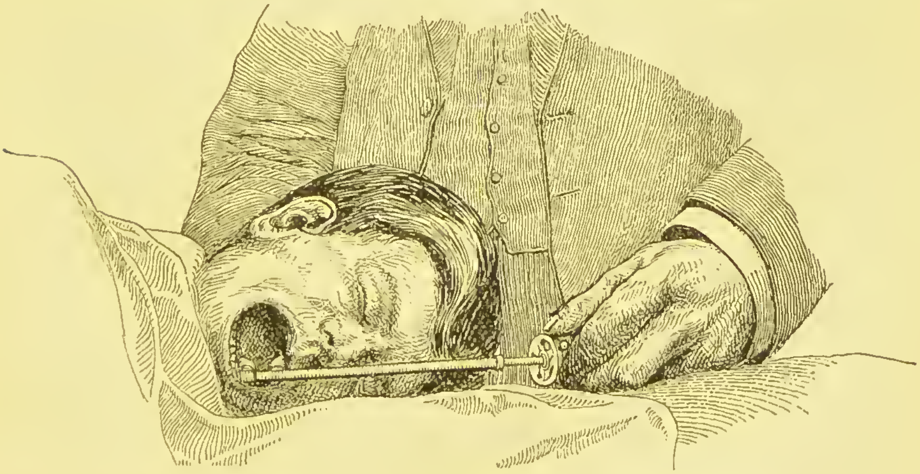

FIG. 53.—Screw-Gag of Fig. 52 in position. From a photograph.

B. THE EFFECTS PRODUCED BY THE ADMINISTRATION OF CHLOROFORM.

There is certainly no therapeutic agent which has given rise to so much discussion and controversy as chloroform. It is, indeed, a curious fact that such totally opposite views respecting the merits and demerits of this anæsthetic should have prevailed for so long a period. Whilst no one can deny the very great advantages of, and even the necessity for, chloroform in certain cases, opinions are still divided as to the suitability of this agent for general surgical purposes. Although we deplore the absence of that unanimity which undoubtedly should exist on so vital a question, we may with certainty affirm that we are at last within a short distance of the termination of this chaotic controversy. We have not arrived at this desirable point by reason of any great assistance that we have received from the physiological laboratory, but in consequence of the increasing and overwhelming weight of clinical facts. Whilst physiological researches upon the lower animals have, if anything, tended to make the ether *v.* chloroform balance swing towards chloroform, bedside observation has had an exactly opposite effect, and has pointed to ether as a far safer and better anæsthetic for routine use. (See 'Selection of the Anæsthetic,' p. 65.) To attempt to present to the reader an intelligible summary of the numerous, but unfortunately conflicting, physiological researches which have been made concerning the *modus operandi* of chloroform would be out of place in a work of this kind. We are only concerned with the practical aspect of the chloroform question. We have, in fact, to consider the effects of this agent from a clinical stand-point; to carefully study the various phenomena which make their appearance during its administration; to compare the chloroform with the ether anæsthesia, and mark the similarities and dissimilarities; to investigate as far as lies in our power the nature and mode of onset of those dangerous symptoms which occasionally arise during the inhalation; to inquire what influence the performance of an operation has in modifying the usual phenomena of the administration; in a word, to bring to a focus the rays of light which have been generated by prolonged practical experience and observation.

The phenomena of chloroform anæsthesia are in their *main* features so similar to those which have been already described as characterising the use of ether, that it will probably be better to compare the former with the latter than to specially describe the phases through which the patient passes whilst inhaling chloroform.

First Degree or Stage.—The vapour of chloroform is more pleasant to inhale than that of ether. When given with a copious supply of air, the sense of suffocation, which is not infrequently complained of with ether, is reduced to a minimum. Swallowing, coughing, holding the breath, &c., symptoms which almost invariably attend the administration of ether by the open method, are rarely observed with chloroform. In other respects the initial phenomena are identical in the two cases.

Second Degree or Stage.—If we compare the open methods of administering the two anæsthetics, we may say that mental and muscular excitement are somewhat less common with chloroform than with ether. But if we compare the open mode of administering the former with the usual (close) plan of exhibiting the latter, we may unhesitatingly state that ether has very great advantages over chloroform in this direction. Shouting, gesticulation, screaming, &c., are all more common under chloroform than under ether, provided the latter is properly administered by means of a close inhaler. Muscular and alcoholic subjects, as well as hysterical and excitable patients, may give a little trouble during the period of rigidity, not only by incoherently gesticulating and attempting to rise into the sitting posture, but by holding the breath, moving the arms and legs, &c. Prolonged tonic spasm should make the administrator cautious, and though he should not, as a rule, discontinue the administration, he should not too rashly push the drug. An occasional breath of fresh air should be allowed, and the inhalation should be entirely suspended for a few moments should any clonic movements appear. The fine tremor which is occasionally met with under ether (see p. 154) does not occur with chloroform. The frequency of temporary respiratory embarrassment in vigorous patients under chloroform probably helps to explain the comparative frequency of fatalities in such patients early in the administration. A continuous, and yet not too sparing an administration, with the careful avoidance of that strength of vapour which might cause 'holding of the breath,' will, in most cases, ensure an absence of inconvenient struggling and hampered breathing. There can be no doubt, that when all the muscles of the body are contracted and the respiratory movements for the moment suspended, the right heart is somewhat over-full, and air is needed in order to allow of that free pulmonary circulation which is essential for the escape of the imprisoned blood to the left cavities. In this way the irregular breathing which marks the second stage in certain subjects passes quietly and satisfactorily away, and leaves a softly snoring form of respiration which indicates the approach or actual presence of the third degree of anæsthesia.

It occasionally happens, however, that instead of the respiration undergoing the usual changes here described, it becomes inaudible and almost imperceptible. There can be no doubt, that, as a general rule, this kind of breathing is the result of too cautious and too sparing a use of the anæsthetic; and that by a bolder administration (see p. 193) it may be obviated. Should this unsatisfactory form of breathing once become well established, however, the administrator may have some difficulty in getting out of the dilemma which he himself has created. The shallow movements prevent a free entrance of the vapour, and the advent of true anæsthesia is thereby delayed. So far as my own experience goes, I am inclined to regard the shallow breathing (which is not infrequently associated with some pallor and feebleness or slowness of pulse) as an indication, at all events in many cases, of a tendency to vomit, although others place a different interpretation upon it. If the administration be carefully continued, the symptoms may often be dispelled, and vomiting averted: the breathing will become deeper, and the colour and pulse better. Sometimes, however, it is difficult or impossible to get the patient out of the condition without vomiting occurring. Should the anæsthetic be entirely withheld, the latter event will be particularly liable to take place, and, after retching movements have subsided, the colour will return, and no further trouble will be experienced.

In some instances loud palatal stertor comes on early in the second stage, and should be disregarded, as it does not indicate the profound anæsthesia which it might suggest. In others, the respiration is very deep and hurried throughout, but such cases are exceptional.

The behaviour of the circulation will depend upon many circumstances. In most cases there is a tendency, as surgical anæsthesia approaches, for the initial acceleration of the pulse to gradually subside, and for a full regular pulse of about the normal rate to become established. Any interference with free respiration, such as that which would arise from tonic spasm of the respiratory muscles during the period of excitement, reflex laryngeal closure, &c., will very quickly and markedly modify the rate, regularity, and fulness of the pulse. The swallowing, coughing, retching, and vomiting, which are prone to arise when chloroform is improperly administered, are one and all similarly liable to interfere with cardiac action. As nothing is so favourable to the occurrence of these symptoms as an intermittent and sparing use of the anæsthetic, we can readily understand the occasional existence of a feeble pulse comparatively early in chloroform administration. The half-asphyxiated condition into which a patient passes when his air-way is intermittently occluded, or rendered temporarily useless for respiratory purposes in consequence of muscular spasm, rapidly tends to embarrass his heart's action during the inhalation of chloroform. As already mentioned, there is not nearly the same liability to these results under ether. The important effects upon circulation dependent upon the commencement of an operation during this stage of anæsthesia will be fully considered below (p. 227).

The pupils during this part of the administration are, as a general rule, mobile and more or less dilated. They react sluggishly or possibly not at all to light. As the third stage of anæsthesia approaches they usually show a marked tendency to become smaller and more fixed. I find in Dr. Sheppard's notes 53 cases in which the pupil was observed before full chloroform anæsthesia was established. In 26 it was "moderately dilated" or "dilated;" in 15 "moderately contracted;" and in 12 "contracted."

Third Degree or Stage.—The phenomena of deep surgical anæsthesia under chloroform, when uncomplicated and satisfactorily developed, are very similar to those which have been described as occurring with ether. There are, however, certain remarkable differences.

The **respiration** is usually regular, softly snoring, and somewhat quicker and deeper than normal.[1] Generally speaking, more of the anæsthetic will produce a louder stertor; and less will lead to quieter breathing. In some cases there is loud stertor, whilst in others the respiration, though satisfactorily performed, is almost or wholly inaudible. Plethoric, flabby, and stout subjects are more liable to stertor than others, and in these especially the jaw may have to be kept pushed well forwards in order to maintain free respiration (see p. 291). There is, however, with chloroform not quite so great a tendency to rigidity of the masseters and adjacent muscles as there is with ether, and it is therefore less common to have to keep the jaw forwards during the administration. When the respiration, instead of being loudly audible, is very quiet or even inaudible, as it may be without any cause for anxiety, the administrator will usually find it possible to induce a soft snoring sound by pressing the lower jaw backwards. The respiratory movements under chloroform are not, as a rule, so deep, so quick, or so noticeable as those met with under ether; and hence some doubt may occasionally be felt as to the efficiency of the breathing. There are various circumstances which may modify respiration during chloroform inhalation, even though an anæsthesia of considerable depth be present. The commencement of the operation will, for example, usually cause deeper respiratory action, more especially if the administrator has not secured full, regular, and slightly snoring breathing before the knife is employed. A crowing laryngeal sound, moreover, is prone to accompany inspiration in some cases. This sound indicates a tendency to closure of the larynx, probably at its superior aperture. I have met with it principally in abdominal section, and in operations upon the genito-urinary organs. As will subsequently be pointed out, this tendency to reflex laryngeal closure, which is known by a high-pitched crowing noise, may constitute a source of trouble in chloroform administration. Looked at from all points of view, the respiration during deep chloroform anæsthesia, though favourable by reason of its comparative tranquillity to the performance of many operations, is not as satisfactory as the respiration under ether. Whilst the breathing of the patient under chloroform is occasionally difficult of appreciation, that of a patient under ether is always obvious to the administrator, usually distinctly audible, and a never-failing guide in case of doubt.

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[1] All varieties of respiration may be met with. I have, for example, notes of a case in which, during deep anæsthesia for an abdominal section, the patient—a female aged 42, of average appearance—breathed at the rate of 62 per minute.

Much discussion has arisen concerning the **circulation** in deep chloroformisation. Those who have been accustomed to the excited cardiac action, the bounding and somewhat accelerated pulse, and the general vascular fulness[1] of etherisation, will be struck by the comparatively sluggish circulation of the patient under chloroform. That the heart's action under the latter anæsthetic is in most cases sufficiently well maintained, there can be no doubt. When the administration has been conducted in the proper manner, and temporary cardiac depression consequent upon too sparing a use of chloroform, or upon respiratory embarrassment, has been avoided, the administrator will find that the pulse becomes slower and steadier than it was during the first and second stages, and that it settles down to about the normal rate or even less than this.[2] It is not unusual to find the almost

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[1] Surgeons who have for many years operated under chloroform, often bear excellent testimony to the more vigorous circulation of ether, in their complaints as to the greater vascularity when operating under the latter agent.

[2] An abnormally slow pulse may point to an unnecessarily deep anæsthesia. I have frequently found that when the pulse is very slow less of the anæsthetic will increase its rate. A normally slow pulse will still be slow during deep anæsthesia. I have known a pulse of 46 per min. throughout the administration, the patient, a woman of 75 years, normally possessing a slow pulse. In 20 patients in whom Kappeler compared the pulse of deep chloroform anæsthesia with that observed a few hours before the administration when the patient was not excited, he found a diminution in rate of from 4 to 30 beats per min. Thus, in a child of 12, a pulse of 80 fell to 50; in a man

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imperceptible pulse of a feeble subject grow markedly stronger under the finger as surgical anæsthesia approaches.

During deep chloroform anæsthesia the **eyeballs** are either fixed, or one may be fixed whilst the other slowly moves, or both may slowly move. The loss of associated movements was pointed out by Dr. F. Warner[1] in 1877, and generally indicates a considerable and proper depth of narcosis. The eyeballs, if fixed, are usually in the horizontal plane.

The **pupil** during the stage of surgical anæsthesia under chloroform has given rise to much comment, and is well worthy of careful study. Budin and Coyne were the first to direct particular attention to the pupil as a guide. All observers agree that it is usually contracted in deep chloroform anæsthesia; but the term 'moderately contracted' seems to me to be more appropriate. By taking measurements with a pupillometer,[2] I find that in most cases the pupil measures from 2 to 3 mm. in diameter (● to ●), usually being about 2½ mm. (●). The average chloroform pupil is therefore decidedly smaller than the average ether pupil. The two resemble one another, however, in that they behave in a similar manner in response to an increase or decrease in the quantity of the anæsthetic given, and in that they are similarly affected by light and other stimuli. As will be pointed out below, the pupil is often of great service as a guide in chloroform administration. Occasionally, as with ether, the pupil remains widely dilated throughout this stage, even though the anæsthetic has not been pushed too far. This is often the case during operations upon cervical glands. A very small pupil (1 or 1½ mm.) in most cases indicates a light anæsthesia; whilst a somewhat dilated pupil (3½ to 4½ mm.) usually means either that the anæsthesia is very profound, or more probably, that the dilatation is of reflex origin, and is associated with a light anæsthesia. As already stated when dealing with ether, very little reliance is to be placed upon the pupil as a guide until after the operation has been in progress some little while, and until the administrator has satisfied himself as to its behaviour with more and less of the anæsthetic. The following table will show the size of the pupil observed in sixteen cases immediately before the opera-

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of 60, a pulse of 60 fell to 52; and in a man of 56, a pulse of 72 fell to 48. I must refer the reader to Kappeler's book for sphygmographic tracings of the pulse under chloroform. The Glasgow Anæsthetics Committee of the British Medical Association found that of 50 cases in which chloroform was given for surgical operations, 5 presented a pulse of 64, 7 of 60, 5 of 56, and 1 of 48 during deep anæsthesia (*Brit. Med. Journ.*, Dec. 18, 1880, p. 958).

[1] *Brit. Med. Journ.*, March 10, 1877, p. 292.

[2] I have used Mr. Edgar Browne's pupillometer in these observations. See *Brit. Med. Journ.*, vol. ii. 1886, p. 24.

tion, the patient on each occasion (with the exception, perhaps, of cases Nos. 6 and 11) being deeply anæsthetised by chloroform—

No.	Description of Patient.	Size of Pupil just before Operation Commenced.	Remarks.
1	F. æt. 35. Healthy.	● to ● (2½ to 3 mm.)	
2	M. Average middle-aged man.	● to ● (3 to 3½ mm.)	
3	F. æt. 73. Thin.	● (2½ mm.)	
4	M. æt. 25. Tall and well built.	● (2½ mm.)	
5	M. æt. 3. Florid.	● to ● (3 to 3½ mm.)	
6	Child æt. 2. Fairly nourished.	● to ● (4 to 4½ mm.)	Slight movement when operation began. Probably not deeply enough under.
7	F. æt. 16. Healthy in appearance.	● to ● (2½ to 3 mm.)	
8	F. æt. 74. Thin.	● to ● (2½ to 3 mm.)	
9	F. æt. 65. Florid, alcoholic, and a little bronchitic.	● (3½ mm.)	
10	F. æt. 47. Very emaciated.	● (2½ mm.)	
11	M. æt. 19. Healthy and well built.	● (3½ mm.)	He was not as deeply under as intended, and there was slight movement with incision, and reflex enlargement of pupil.
12	M. æt. 22. Well built.	● (3 mm.)	
13	F. æt. 19. Tall and healthy looking.	● (3 mm.)	
14	F. æt. 42. Average.	● (2½ mm.)	
15	F. æt. 15. Healthy looking.	● (3½ mm.)	
16	F. æt. 6. Healthy country child.	● (3½ mm.)	

From the above table it will appear that in 15 out of the 16 cases, the pupil measured from 2½ to 3½ mm. in diameter, and in the other case. from 4 to 4½ mm., immediately before the operation was commenced. With two exceptions the patients were all very deeply anæsthetised; and in these two cases the pupil measurements were respectively 4 to 4½ mm. and 3½ mm.[1] The late Dr. Sheppard paid particular attention to the chloroform pupil, and I am indebted to him for much valuable information. I find in his notes that the size of the pupil in deep chloroform anæsthesia is recorded in 277 cases; and I have arranged his records in the following tabular form—

FROM DR. SHEPPARD'S NOTES.

Condition of the Pupil during Deep Chloroform Anæsthesia.	Cases.
Moderately contracted in . . . . (Active to light in 40 : inactive in 5 : at one time active and at another inactive in 1 : reaction not stated in 116.)	162
Contracted or very contracted in . . . . (Active to light in 1 : inactive in 2 : reaction not stated in 54.)	57
Alternating between moderately contracted and contracted in . . (The moderately contracted pupil acted in 3 : no note as to action in 12. The contracted pupil inactive in 4 : no note as to action in 11.)	15
Moderately dilated in . . . . (Active to light in 2 : at one time active, at another inactive in 1 : reaction not stated in 10.)	13
Alternating between moderately contracted and dilated in . . . (No note as to reaction of moderately contracted pupil in any case.) (Dilated pupil active in 1 case : inactive in one case : and no note in 8 cases.)	10
Dilated in . . . . (Active to light in 1 : inactive in 2 : no note in 6.)	9
Alternating between moderately contracted and moderately dilated in . (Moderately contracted pupil active in 1 case : inactive in 1 case : no note in 2.) (Moderately dilated pupil active in 2 : no note in 2.)	4
Carry forward	270

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[1] For further information see an interesting article in the *Lancet*, vol. i. 1875, p. 550. Also a paper by Dr. H. J. Neilson, *Brit. Med. Journ.*, July 30 and Oct. 1, 1887. I cannot agree with Dr. Neilson's contention that when the pupil is strongly contracted and immobile, no chloroform should be given until it begins to dilate again. A very small pupil is, I believe, almost invariably indicative of a light form of anæsthesia, and in most cases denotes the need for slightly increasing the chloroform.

From Dr. Sheppard's Notes—(*continued*).

Condition of the Pupil during Deep Chloroform Anæsthesia.	Cases.
Brought forward . . .	270
Alternating between contracted and dilated in . . . . . . (Reaction to light not stated.)	3
Alternating between moderately contracted and very dilated in . . . (Moderately contracted pupil active in 1 : no note in 1.) (Very dilated pupil inactive in both cases.)	2
Alternating between moderately dilated and dilated in . . . . . (In one case the moderately dilated pupil acted to light : in the other there is no note.) (No note as to reaction of dilated pupil.)	2
Total number of cases	277

The **lid-reflex** should, as a general rule, be absent. There are, of course, exceptions to this rule, but the third degree of anæsthesia cannot, generally speaking, be said to be present when this reflex phenomenon can be elicited.

The **muscular system** is completely relaxed under chloroform. With ether a slight degree of rigidity may persist for some time, even though the anæsthetic be very freely used ; but with chloroform this is very rarely the case.

The normal **colour of the face** is usually at first somewhat heightened, provided that conditions capable of leading to circulatory depression or to obstructed breathing are absent. Should the patient be allowed to come out of a deep anæsthesia, pallor indicative of the approach of retching may result. Or should an inadequate nasal or oral air-way exist, from pursing up of the lips or other causes, a slight degree of cyanosis would result. As much more air is admitted with chloroform than with ether, there is as a rule less duskiness of the features. After deep anæsthesia has been established for a short time there is a tendency for the face to become paler than normal, and this tendency persists for the remainder of the administration unless abnormally deep breathing, coughing, or vomiting should occur.

Mucus and **saliva** are rarely secreted in sufficient quantities to attract attention. The excessive secretion of these fluids which occurs in florid young patients under ether is rarely if ever observed under chloroform.

The **temperature**, according to Kappeler, who has made many observations on this subject, is invariably reduced during the administration of chloroform. In thirty cases in which operations were performed under chloroform, the reduction varied from 0°.02 C. to 1°.1 C., the average being 0°.59 C.

C. DANGERS CONNECTED WITH THE ADMINISTRATION.

General Considerations.

There is much discrepancy of opinion as to the usual causes and mode of onset of dangerous symptoms during the inhalation of chloroform for surgical operations. We can readily understand this when we reflect that patients display great variation in their behaviour under anæsthetics, and that there are many circumstances which are capable of exerting their special influences during the induction and maintenance of surgical anæsthesia. We hardly ever meet with two patients who exhibit precisely similar phenomena; and the manner in which a patient 'takes chloroform,' as the expression goes, for a surgical operation, will be found to depend upon numerous circumstances. Amongst these may be mentioned:—

(*a.*) The method of administration.
(*b.*) The general physique of the patient.
(*c.*) His susceptibility to the anæsthetic, *i.e.*, the quantity required to produce a given effect.
(*d.*) The tendency which he displays to reflex alterations in respiration and circulation in response to various stimuli.
(*e.*) The nature of the operation which is being performed.
(*f.*) The conformation and capacity of his upper air-passages, and the consequent liability or non-liability to obstructed respiration.
(*g.*) His position during the administration of the anæsthetic.

There are many other circumstances, but these appear to be the most important. With such considerations as these before us it is obvious that dangerous or fatal symptoms during chloroformisation may arise in many ways—certainly in more ways than have hitherto been recognised by physiological observers.

It is questionable whether the most carefully conducted physiological experiments on the lower animals will ever satisfactorily explain all cases of death during the administration of chloroform to human beings. From the difficulties which many able workers in the physiological field have had in producing in the lower animals under chloroform certain phenomena which have over and over again been witnessed in human beings, it would appear that we are hardly justified in drawing any important inferences from the behaviour of the former during the inhalation of this anæsthetic. I refer more particularly to reflex alterations in the circulation, which are undoubtedly prone to manifest themselves, *more especially in certain degrees of anæsthesia, in certain operations, and in certain subjects*, during the inhalation of chloroform.

A study of the numerous experiments made by the late Dr. Snow, the Committee of the Royal Medical and Chirurgical Society, the Glasgow Committee, and the Hyderabad Chloroform Commission, will reveal the fact that there are obvious differences between the chloroform phenomena witnessed by the physiologist, and those with which we are familiar in the operating theatre. This is, I believe, conceded by most of those who have had extensive experience in both departments of investigation. It is obviously unreasonable to assume that the dog, when subjected to a surgical operation under chloroform, will display the same nervous, circulatory, and respiratory phenomena as a highly civilised and sensitive human being. It is unnecessary to have had more than a short acquaintance with the effects of general anæsthetics to recognise the fact that, in certain types of subjects—I particularly refer to those of highly-strung and nervous temperaments—there is a greater tendency than in other types for various reflex circulatory and respiratory[1] phenomena, to which I shall subsequently refer, to arise; and if this be so when comparing one human being with another, how much greater will the contrast become when we compare the higher with the lower mammals?

There is one important clinical fact which stands out in relief when we come to discuss in an unprejudiced manner the mode of onset of dangerous symptoms during chloroform inhalation. It is that patients under this anæsthetic are prone to exhibit symptoms of cardiac depression. Let us suppose that 500 consecutive surgical operations are to be performed under chloroform, and that the pulse of every patient is to be watched from the commencement to the end of the inhalation. Now, whatever views the observer may have, he cannot fail to report that in a certain proportion of the cases the pulse gives indications of feeble or embarrassed cardiac action. The chloroformist who never observes the pulse, but attends only to the respiration, will not note these alterations. Whether such alterations are connected with a too free use of chloroform, whether it is *necessary* to note them at all, or whether they should be taken to indicate that the patient's condition is one of danger, does not concern us here. All that I wish to point out in the present place is that evidences of feeble circulation, whatever may be their cause, whatever their significance, are more common and pronounced during the use of chloroform than during that of ether. That skilful and watchful administration greatly tends to lessen the chances of circulatory depression under chloroform there can be no doubt. By a continuous and free use of chloroform; by securing a deep anæsthesia before the patient is touched with the knife; by keeping a free air-way; and by maintaining a profound narcosis for the whole of the operation; all serious circulatory changes may, as a rule, be prevented. Simpson, Syme, and Lister have done much towards pointing out the proper manner in which chloroform should be used; and when it is exhibited with judicious, but not reckless freedom, the chances of cardiac depression are very greatly reduced, and the risk to life is shifted from the circulatory to the respiratory side. But so long as chloroform is used as an anæsthetic for general purposes, so long will numerous accidents occur. The workable area under chloroform is small as compared to that under ether. In the case of ether the risk to life is almost entirely connected with an over-dose of the drug, whereas with chloroform we not only have this danger to avoid, but we know by experience that an imperfectly developed anæsthesia is hazardous. The half-anæsthetised patient under ether does not exhibit that liability to cardiac failure from operative procedures, intercurrent asphyxia, and other causes, which in the case of chloroform is certainly present. In these considerations lies the great difference between these two important anæsthetics.

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[1] Now that the fact is established that all asphyxial conditions are highly dangerous during the inhalation of chloroform, it is surely important to ascertain whether the lower animals are, or are not, prone to exhibit those modifications in respiration which often constitute the first step towards the 'chloroform syncope' so repeatedly described in the medical journals. It is quite possible, and indeed probable, that the lower mammals are not so susceptible as human beings to the various forms of respiratory embarrassment occasionally met with in actual practice. In the *Transactions of the Royal Medical and Chirurgical Society*, vol. lxxiv. 1891, p. 107, will be found a paper which I wrote on this subject, entitled 'Clinical Observations upon Respiration during Anæsthesia; with Special Reference to the Causes of Embarrassed and Obstructed Breathing.' It would be interesting to learn from physiological investigators whether the various conditions to which I have referred in this paper, and which may play an important part in bringing about cardiac failure during the use of chloroform in man, have their analogues in the lower animals.

The susceptibility of the particular patient to chloroform is a matter of some importance in any inquiry concerning the supervention of dangerous symptoms. Billroth, Robert, and other competent authorities believe that, as with morphine, iodide of potassium, and other drugs, patients may display very marked susceptibility to chloroform, and may thus exhibit toxic symptoms from doses which in the vast majority of cases would have no such deleterious effects. This constitutes the so-called idiosyncrasy under chloroform.

A peculiar feature of the chloroform anæsthesia is that vigorous subjects are more liable than others to succumb from the effects of this agent. Young adults of good colour and physique usually give greater trouble to the anæsthetist than feebler and more fragile subjects. Children, old persons, and those patients who have become weakened by disease, usually take chloroform well. In the subjoined analysis (p. 215) of 210 fatal cases of chloroform inhalation it will be seen that one half of the number occurred in patients between the ages of 16 and 45, *i.e.*, during the most vigorous period of life. As will also be seen, men are more prone to succumb under chloroform than women; about two-thirds of the patients were males. The better developed muscular system of men is probably responsible for this difference. Other things being equal, the greater the vigour of the patient the greater will be the tendency to the development of muscular spasm, not only of the extremities but also of the respiratory muscles, masseters, muscles of the floor of the mouth, larynx, and other parts. Such spasm may either occur independently of any operative interference, as the patient is just entering into the state of complete surgical anæsthesia, or it may be directly due to some surgical procedure. Prolonged tonic spasm under chloroform is more hazardous than a similar condition under ether, probably because the overloaded state of the right side of the heart to which it inevitably leads is, in the absence of a stimulant such as ether, liable to be followed by syncope of the worst form. In this way many of the fatalities under chloroform are to be explained.

A considerable proportion of patients who have died during chloroform administration have succumbed before anæsthesia became completely established, *i.e.*, either within the first minute or two, or during the stage of excitement. Of the 210 cases referred to below, the period at which death occurred is stated in 75 cases only, *and in 68 of these (i.e., in 90 per cent.) the patients died within the first fifteen minutes.* Comte[1] collected 232 deaths under chloroform. In 224 of these the time at which the fatal event occurred was mentioned; and of these 224 deaths, 112 (50 per cent.) took place before anæsthesia was complete. I myself find 130 chloroform deaths reported in the *Lancet* and *British Medical Journal* from 1880–1889 inclusive; and of these, 54 took place either before the operation, or during some short and trivial operation.

There can be no doubt, as pointed out by Snow, Clover, the English Chloroform Committee, and Paul Bert, that the dangers of chloroformisation may be lessened by keeping the proportion of vapour to the air breathed below 4 or 5 per cent. Too concentrated a chloroform vapour is certainly dangerous; but the precise manner in which such a vapour kills has yet to be demonstrated. Moreover, several cases are on record in which, even with Clover's chloroform apparatus,[1] which supplies the anæsthetic properly diluted with known quantities of air, a fatal issue has occurred. As will be frequently urged, there is about as much risk from administering too little as from administering too much chloroform ; and those who advocate the employment of a fixed percentage of vapour must occasionally find that the atmosphere employed is too dilute for securing the safer, *i.e.*, the more profound form of anæsthesia.

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[1] Quoted by Julliard, *L'éther: est il préférable au chloroforme?*

Before studying the nature of the threatening symptoms which may be evinced by patients under chloroform, it may not be out of place to refer to the following analysis of 210 chloroform fatalities. The Committee appointed by the Royal Medical and Chirurgical Society in 1864, to inquire into the uses and effects of chloroform, collected and analysed 109 fatal cases which occurred in the years 1848–1863 inclusive. Kappeler, in his valuable work on anæsthetics, gives a similar analysis of 101 additional fatalities, which have been recorded in various journals as having taken place in the years 1865–1876 inclusive. As the matter is one of importance, and as Kappeler's work in this direction is not perhaps as widely known in this country as it deserves, I propose to present to the reader a combined analysis of the 210 cases.

An analysis of 210 *chloroform fatalities* (=109 *collected by the Committee of the Royal Medical and Chirurgical Society, and* 101 *collected by Kappeler*).

(a.) *Sex.*

Males	150
Females	59
Not stated	1
	210

(b.) *Age.*

Under 5 years	2
6–15 years	21
16–30 „	49
31–45 „	53
46–60 „	37
Over 60 years	3
Not stated	45
	210

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[1] This apparatus was used in 5 of the 101 fatal cases collected by Kappeler.

(c.) *Nature of Operation.*

Amputations	36
Dislocations	16
Removal of tumours	17
Examination of injuries (including putting up of fractures)	9
Operations on male genito-urinary organs	20
Operations on anus, rectum, &c.	11
Operations on female genital organs	5
Operations on eye	16
Hernia	3
Castration	4
For necrosis, excision of bone, &c.	7
Excision of joints	2
Forcible straightening of joints	7
For application of escharotics	8
Plastic operations	6
Ligature of arteries	1
Opening abscesses and sinuses	7
Impaction of fæces	1
For removal of teeth	18
Removal of toe-nail	5
For relief of neuralgia	2
For delirium tremens	2
For maniacal excitement	1
Not stated	6
	210

(d.) *Period of Inhalation at which Death Occurred.*

Under 1 minute	10
1–3 minutes	13
3–5 "	12
6–15 "	33
Over 15 minutes	7
Not stated	135
	210

(e.) *Stage of Anæsthesia at which Death Occurred.*

Commencing to inhale	14
Stage of excitement	30
Incomplete anæsthesia	49
Fully under influence	68
After operation	31
Not stated	18
	210

Or, Before full effects of chloroform	93
During full effects	68
After operation	31
Not stated	18
	210

(f.) *Mode of Death.*

It is best, perhaps, to keep the two analyses under this heading separate.

Royal Medical and Chirurgical Committee.

"Syncope	56
Syncope during stage of excitement	6
Died suddenly	6
Died in a fit	10
Pulse and respiration ceased together	9
Failure of respiration (pulse not noted)	6
Failure of respiration (pulse remaining)	2
Not stated	14
	109"

Kappeler.

Group 1. Imperfectly recorded cases, or cases in which death could not be ascribed directly to chloroform	61
Group 2. Fully reported cases in which death occurred as the immediate result of chloroform	40
	101

Analysis of Group 2.

A. Death with primary evidences of circulatory failure (14 fully under and 9 partially under chloroform)	23
B. Cases in which respiration ceased first (10 fully under and 7 partially under chloroform)	17
	40

(g.) *Mode of Inhalation.*

On handkerchief, towel, napkin, or lint	87
Lint with sponge	5
On sponge	11
With an ether inhaler	2
Snow's inhaler	5
An inhaler	23
Paper bag or cloth cone	3
Skinner's mask	2
A mask	1
Esmarch's mask	5
Metal inhaler with plenty of air	2
Clover's apparatus	5
Not stated	59
	210

SPECIAL CONSIDERATIONS.

1. The Administration of an Over-dose: Fourth Degree or Stage.—There is good reason to believe that fatalities occurring, strictly speaking, from an over-dose of chloroform are not as common as is generally imagined. Cases nevertheless do occur in which it is quite clear that the accident or fatality which has taken place has been caused by too large an intake of the anæsthetic. The Hyderabad Commission has specially laid stress upon the possibility of this occurring during the deep and gasping respirations which attend or follow upon struggling.[1] Later on in the administration, too, when breathing is not abnormally jerky, an over-dose may easily be administered.

As in the case of ether, the phenomena which depend upon the administration of an over-dose will be found to be associated with an insensitive conjunctiva. So long as the lid-reflex is present, any dangerous symptoms which the patient may evince are usually to be ascribed to other causes than an excessive dose of chloroform.

The symptoms which *collectively* indicate the supervention of this stage are :—Impairment or complete cessation of respiration ; an abnormally slow, feeble, or 'running' pulse, which tends to become irregular and imperceptible; moderate dilatation of the pupils, increasing in severe cases to wide dilatation; complete absence of the lid-reflex; a dusky pallor of the complexion ; and a separation of the eyelids. As will be seen by referring to Chapter II. of this Part, these phenomena are very similar to those which arise from an over-dose of ether, with the exception that the circulation is more profoundly affected, as evidenced by the greater degree of pallor and pulse-failure.

Should the administration have been conducted rapidly, recklessly, and without the important precaution of admitting a sufficient quantity of air, the patient may so suddenly die, that all attempts on the part of the administrator to recognise the order in which the fatal symptoms have arisen may be completely futile. In such cases as these the peripheral circulation may fail before respiration ceases.[2] The moment at which the action of the heart comes to a stand-still hardly concerns us here. We are only concerned with the fact that failure of the *circulation*, as recognised by the absence of the wrist-pulse, may precede stoppage of breathing. It seems highly probable, from physiological considerations, that in many of the fatal cases in which this sequence of events has been noticed, cardiac action has in reality persisted for a longer period than external pulse-evidence would suggest. This view is also rendered probable by the clinical fact that patients possessing no outward manifestations of the continuance of circulation, but exhibiting feeble respiration, have over and over again been resuscitated[1] by prompt measures. Had cardiac action ceased no such recovery could have been brought about.

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[1] See an interesting illustration of this published (*Lancet*, Oct. 1, 1892, p. 796) by Surgeon Lieut.-Col. E. Lawrie.

[2] One of the best reported cases illustrating the mode of death from a concentrated chloroform atmosphere is to be found in the *Brit. Med. Journ.*, Oct. 25, 1884, p. 811.

When toxic quantities of chloroform are more gradually given, the symptoms displayed by the patient will be more capable of differentiation and analysis; although the period which elapses before such symptoms culminate in total cessation of respiration and peripheral circulation will still be very short—far shorter indeed than in the case of ether. Obvious impairment of breathing is generally noticeable before thoracic and abdominal movements altogether cease. Respiratory arrest of this nature is usually, if not always, of a non-obstructive character. There may be gasping, jerky, and irregular respiratory movements immediately before the actual cessation. A short, hurried form of breathing[2] not infrequently indicates a dangerous depth of anæsthesia; and sudden stoppage of all respiratory movements may take place during these short quick breaths. Snow stated that thoracic movements usually cease before abdominal.

The stoppage of respiration, which has as its immediate cause a spasmodic condition of the respiratory muscles, appears to be more frequently connected with partially established anæsthesia than with the presence within the circulation of poisonous quantities of the anæsthetic (*vide infra*).

The same may be said of arrested breathing resulting from laryngeal closure. It is right, however, to add, with regard to this condition, that Sir Joseph Lister regards a falling together or spasm of the arytæno-epiglottidean folds, which, he asserts, occasionally takes place under chloroform, as connected with and indicating a too profound degree of narcosis. But, for reasons which will be elsewhere given, there is evidence to show that laryngeal occlusion is very frequently associated with imperfectly established anæsthesia. I propose, therefore, to discuss this condition, as well as fixity of the chest, in the following section of this chapter (2. Respiratory Failure occurring Independently of an Over-dose).

At the moment when respiration fails from an over-dose of chloroform the pulse is usually very slow and feeble, or cannot be detected. Chloroform compares unfavourably with ether in this respect; for, with the latter, respiratory failure from an over-dose is not associated with anything like the degree of cardiac depression which obtains with chloroform. Even if we admit that respiration invariably ceases before the action of the heart, we cannot lose sight of the fact that death from an over-dose is, in its main features, a cardiac death. If it could be shown that, as with ether, the peripheral circulation continues *for a considerable time* after respiration has ceased, we might then see our way to regarding chloroform in the light of a purely respiratory depressant.

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[1] For good illustrations see *Edin. Med. Journ.*, 1853, vol. xvii. p. 211.

[2] See *Edin. Med. Journ.*, *loc. cit.*, p. 216, Case III.

This would appear to be the most appropriate place to refer to those cases in which, during deep and satisfactory chloroform anæsthesia, the circulation shows distinct signs of failure, whilst respiration is proceeding with regularity and efficiency. Such cases are probably of less importance than one might at first sight suppose. But that they do occur there can be no doubt. Kappeler relates two examples of the kind. Mr. Mills, Dr. Buxton, and others have also met with such cases. I myself have seen more than one example. Without any ascribable cause (such as the imminence of vomiting, the performance of the operation, &c.) the pulse of the chloroformed patient is found to become extremely slow, feeble, irregular, or intermittent, and the face pale. I have also known a rapid or 'running' pulse to indicate a too free use of the chloroform. All that is usually necessary is to remove the anæsthetic for a while, and the pulse and colour will be found to improve. The symptoms may, however, recur when the anæsthetic is resumed. The condition to which I refer is liable to be overlooked by any one who is watching the respiration and no other sign. What its physiological significance may be I must leave others to decide ; I refer to it here because it disappears when *less* of the anæsthetic is given, and would therefore seem to depend upon too large, rather than too small a dose of the chloroform.[1]

2. Respiratory Failure occurring Independently of an Over-dose.—Hampered and obstructed breathing, similar in every respect to that already described (p. 160) as occasionally occurring in association with imperfectly established ether anæsthesia, may occur under chloroform, and is specially prone to do so in highly nervous, in muscular, and in alcoholic subjects. This embarrassment of respiration during the second stage of chloroformisation demands special care. When the abdomen is hard, the chest fixed, the jaws clenched, and the tongue pressed up against the palate and pharynx, respiration may become completely arrested for a while. The arrest is the result of muscular spasm. Not only do the thoracic and abdominal muscles share in this spasm, but the air-way becomes temporarily closed. There is reason for the belief that any prolonged cessation of respiration from these causes is especially hazardous under chloroform.

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[1] Although the Hyderabad Chloroform Commission has attempted to prove that chloroform does not directly lower cardiac action, the researches of Prof. MacWilliam (*Brit. Med. Journ.*, Oct. 11, 1890, p. 831) and of Drs. Gaskell and Shore (*Brit. Med. Journ.*, Jan. 21, 1893, p. 105) have led these observers to an exactly opposite conclusion. The clinical facts mentioned in the text are of interest as supporting the contentions of MacWilliam, Gaskell, and Shore.

There is a symptom which appears to me to be of some interest in connection with the second stage of the inhalation of chloroform. I refer to a clonic movement affecting the arms, and causing them to be more or less rhythmically jerked towards the median line of the body. It is probable that this convulsive movement of the arms should be regarded as a danger-signal. So similar are these clonic movements to those met with during the period of gesticulation and excitement, that the two are liable to be confounded. Whilst irregular and excited movements invariably call for a steady continuance of the administration, the clonic phenomena referred to, which are apparently due to spasm of the pectoral muscles, strongly indicate the necessity for air. It would seem that this clonic contraction of the pectoral muscles should be regarded as the result of impulses originating in the respiratory centre; and that these muscles come into action as extraordinary muscles of respiration. Owing, however, to the arms having become flaccid, the contraction of the pectoral muscles has no effect in increasing thoracic expansion. All that such contraction can do is to draw the arms towards the trunk. The jerky movements referred to are most conspicuous when the arms are hanging down on each side of the operating table. I have on two occasions known cessation of respiration under chloroform to be preceded by these movements.

In the description of respiratory embarrassment during imperfect etherisation (p. 160), it has been stated that laryngeal spasm under ether rarely if ever gives cause for anxiety. The case is different with chloroform. There are certain cases in which a crowing, high-pitched, inspiratory stridor is met with, uninfluenced in extreme cases either by pushing the lower jaw forwards, or by moderate tongue-traction. Whilst this spasm does not appear to arise during very light anæsthesia, we rarely if ever meet with it in the most profound narcosis. It seems to be connected with a *moderate* degree of chloroformisation. Florid, vigorous patients appear to be more liable to its occurrence than others. One factor in its production seems to be the performance of certain operations; for it is most common in abdominal surgery, and in operations upon the genito-urinary organs. It is often associated with some tendency to swallow or cough. On other occasions it appears to be connected with the presence of a small plug of mucus. In the large majority of cases the administration of more of the anæsthetic causes it to subside; and if very deep anæsthesia be maintained further trouble may usually be obviated. Cases, however, occur in which precisely the opposite treatment, viz., temporary withdrawal of the chloroform, proves efficacious. And there are cases also in which this laryngeal sound, having once become established, still continues in spite of increasing or decreasing the quantity of the anæsthetic. But the most important fact in connection with this condition is that it occasionally leads to complete cessation of breathing, even though an attempt is made to overcome it in the manner described. I have notes of three cases in which forcible traction upon the tongue had to be employed in order to overcome this form of obstruction. All the three patients were florid young adults in excellent health. Two were females: the other was a male patient. Of the two females, one was being operated upon for ruptured perinæum (see Illust. Case, No. 29, p. 294), and the other was just emerging from deep anæsthesia, which had been maintained for one hour for ovariotomy. The male patient was undergoing an operation for the radical cure of hernia, and had been allowed to emerge to a very slight degree from deep anæsthesia. Sir Joseph Lister has drawn attention to the importance of recognising laryngeal obstruction under chloroform. He states[1] that a falling together or spasm of the arytæno-epiglottidean folds not infrequently takes place, and that almost noiseless obstruction to respiration may thus result. He regards this condition as indicating a dangerous depth of narcosis; and there can be no doubt that when symptoms of laryngeal closure arise they may often be relieved by giving less anæsthetic. But from what has been above said, as well as from other considerations (p. 289), the balance of evidence seems rather in favour of regarding all obstructed states of breathing under chloroform as belonging to an imperfectly established anæsthesia, and not as resulting from the presence within the circulation of toxic quantities of the anæsthetic.[2]

Spasm of the respiratory muscles, similar in every respect to that already described as occurring in very rare instances under ether, has also been met with under chloroform.[3]

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[1] 'System of Surgery,' vol. iii. 3rd edition, p. 604.

[2] Dr. Snow does not seem to have recognised this particular danger, though he states (*op. cit.*, p. 234) that, at a trial in France, M. Devergie urged that chloroform was capable of causing death by closure of the glottis. See also a pamphlet by Dr. Black, 'Chloroform: How shall we ensure Safety in its Administration?' London, 1855. Dr. Black believed that all accidents under chloroform were due to closure of the glottis, but attributed this closure to the pungency of the vapour. More recently Ricord, Yvonneau, and Stanelli have dwelt upon the dangers of epiglottic and laryngeal obstruction under chloróform.

[3] See Sir Joseph Lister's account of a chloroform fatality ('System of Surgery,' vol. iii. 3rd edition, p. 615). In this case, which he so graphically

Operations in the neighbourhood of the vagus in the neck may have the effect of temporarily suspending respiration without markedly interfering with cardiac action (see Illust. Case, No. 32, p. 304).

The feebleness of respiration which is immediately dependent upon cardiac depression, from vomiting and other causes, will be considered in connection with circulatory failure.

Lastly, chloroform appears to act sometimes as a direct respiratory sedative, without having been given in excessive doses. The breathing becomes more and more feeble, and the colour of the patient dusky and pale. With these phenomena, the conjunctiva remains sensitive to touch. Rubbing the lips and cheeks briskly with a towel will, in most cases, set breathing going again, and the colour will then improve. As already mentioned (p. 193), the condition is especially liable to occur when chloroform is too sparingly given.

3. Circulatory Failure occurring Independently of an Over-dose. — The circulation of the moderately healthy patient, during the administration of chloroform for a surgical operation, may show signs of failure, or actually cease, from influences quite irrespective of a too free use of the anæsthetic. Clinical evidence leads us to state that the heart's action may become seriously depressed :—

(*a.*) By fright or apprehension at the very outset of the inhalation, *i.e.*, before consciousness has been destroyed.

(*b.*) In connection with suppressed or actual vomiting incidental to a light anæsthesia.

(*c.*) As the more or less immediate result of embarrassed or inadequate respiration.

(*d.*) As the direct effect of the surgical procedure for which the anæsthetic is being administered.

I have not included the supposed reflex effect of chloroform-vapour upon the heart, as our evidence on this point is at present insufficient.

(*a.*) Cases have been recorded in which, at the very beginning of chloroform inhalation, sudden syncope has arisen.[1] Such cases require to be carefully distinguished from those in which cardiac failure arises somewhat later in the administration, *i.e.*, during the period of excitement and struggling. In the cases which we

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describes, the respiration ceased during an epileptiform spasm. A similar condition has been observed under ether (*Brit. Med. Journ.*, May 2, 1885, p. 887).

[1] For typical examples see *Brit. Med. Journ.*, Oct. 5, 1889, p. 778, and Nov. 7, 1891, p. 1004 ; *Lancet*, Nov. 14, 1891, p. 1117. A non-fatal case, recorded by Dr. Snow (*op. cit.*, p. 96), seems to belong to this category.

are about to consider it would seem that excessive mental emotion and apprehension have been principally, if not wholly, responsible for the sudden arrest of the heart's action. Prior to the introduction of anæsthetics, death from fright, either before or at the very commencement of the operation, was by no means uncommon.[1] Dr. Snow,[2] indeed, rightly attributed several of the so-called chloroform fatalities into which he inquired to fear and mental emotion. It is somewhat doubtful, however, whether in cases of this class the chloroform should, in one sense, be wholly exonerated. Similar fatalities are, comparatively speaking, unknown under nitrous oxide or ether—a fact which strongly suggests the presence or absence, as the case may be, of some factor other than fear, in deaths at the very outset of chloroformisation. Ether is, as is well known, a rapidly-acting cardiac stimulant; and nitrous oxide so quickly abolishes consciousness that any apprehension which the patient may feel soon vanishes. Chloroform, on the other hand, is inferior to ether as a cardiac stimulant, and takes a longer time than nitrous oxide to abolish consciousness. It is, therefore, possible, without imputing to chloroform, properly diluted with air, any positively depressing influence upon the circulation at the outset of the inhalation, to explain the infrequency of similar cardiac depression under other more stimulating and more rapidly acting anæsthetics. Too sparing and too slow an administration of chloroform may, by prolonging the period during which consciousness is unaffected, be decidedly favourable in certain subjects to this early syncope. Rapid loss of consciousness, such as that which would result from a continuous and moderately free use of the agent, certainly has an advantage in the case of extremely nervous and apprehensive persons. With these considerations before us it would seem probable that death at the commencement of chloroform inhalation has, as its primary cause, extreme mental emotion and fear; and that the anæsthetic can only be blamed in so far that, unlike ether, it does not produce that intensely stimulating effect upon the circulation which is capable of counteracting the depressing influence of fright. It must be confessed, however, that these exceptional cases are still somewhat shrouded in mystery, and that, before all the clinical facts which have been brought forward can be harmonised, further observation and research are needed. I have never myself witnessed any condition at all corresponding to that here referred to.

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[1] An interesting case is recorded by Kappeler ('Anæsthetica,' p. 118). The patient was a man, æt. 40; an amputation had to be performed. He was so feeble that chloroform was not considered advisable; so a pretence was made to administer the agent by means of a cloth, but no chloroform was used. After four inspirations, respiration and circulation suddenly ceased; the man was dead. This case is interesting because it is in the highest degree probable that a similar result would have attended the use of chloroform, and that the death of the patient would have been attributed to the drug. Sir James Simpson refers to a somewhat similar case, in which a patient suddenly expired during the shaving of the groin, preparatory to an operation for hernia. Other instances of the kind might be quoted. See Sir James Simpson's works, vol. ii. p. 144.

[2] *Op. cit.*, pp. 201–211.

(*b.*) As is well known, the act of **vomiting** may be accompanied by cardiac depression of greater or less severity; and cases are on record in which fatal syncope has thus arisen, during or after chloroformisation.[1] The graver forms, however, of vomiting-syncope appear to be only met with in patients who are at the time in a feeble condition. The more vigorous the patient, the less seems to be the risk of syncope during vomiting. We must remember, however, that the strongest person may be placed in an unfavourable condition, so far as the actual effect of vomiting is concerned, by the faulty and too sparing administration already discussed (p. 193). The half-asphyxiated and feeble state, brought about by a faulty method of administration, is probably favourable to the occurrence of vomiting-syncope. Emaciated and exhausted subjects, such, for example, as those suffering from intestinal obstruction, are particularly prone to succumb under chloroform (or indeed any anæsthetic) during an act of vomiting.

Vomiting never takes place during very profound anæsthesia. It will therefore either arise in the period preceding, or in that following surgical narcosis. When the stomach is full of undigested food, a few breaths of chloroform vapour may be sufficient to cause this organ to expel its contents. But whether food is or is not present in the stomach, a slow and intermittent administration is particularly liable to induce emesis—a fact which may possibly act as a key to some of the chloroform fatalities in which remarkably small doses of the drug have been used.

Symptoms of impending vomiting may occur during chloroformisation, and yet the act of vomiting may never take place. The pallor, feeble pulse, dilated pupil, and shallow breathing are hence often misunderstood, and attributed to the anæsthetic; whereas they may be, in reality, due to too sparing a use of the chloroform. Whether such symptoms, originally developing in association with vomiting, ever end fatally in weakly persons without the supervention of actual retching or vomiting to testify to their nature, is a matter for future inquiry. It is quite possible that the syncope referred to by Dr. Kirk (p. 193) may be of this kind.

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[1] As an illustrative case, see *Brit. Med. Journ.*, July 21, 1888, p. 135, and June 14, 1884, p. 1162.

(*c.*) Physiological research and clinical observation are in complete accord concerning the deleterious effects produced upon the circulation by any **asphyxial complication** during the administration of chloroform. Obstructed or inadequate breathing, from whatever cause arising, quickly interferes with cardiac action—far more quickly than in the case of ether. The danger of the asphyxial element in chloroformisation has been recognised for many years;[1] and the late Hyderabad Chloroform Commission have recently re-directed attention to it.

I have often had occasion to satisfy myself of the marked influence which embarrassed respiration exerts upon the circulation. I have known the pulse of a feeble old man under chloroform to lose its regularity and to become weaker, as the immediate result of slightly hampered breathing, due to the introduction of a Mason's gag; and have observed that such symptoms have passed away directly free respiration has become re-established. I have also seen several cases in which partially obstructed breathing (as from laryngeal spasm, blood in the air-passages, &c.) has been quickly followed by signs of circulatory depression, which signs have passed away when free breathing has become established. Too much stress cannot be laid upon the fact that the so-called 'syncope' of chloroform has frequently been the immediate outcome of respiratory inadequacy or embarrassment, which has been overlooked by the administrator. When dangerous symptoms arise under chloroform, they usually occur in such rapid succession that, unless the anæsthetist be on his guard, he may easily fail to recognise feeble or obstructed breathing; and the first indication of danger apparent to him under such circumstances may be pallor of the features, or loss of pulse—symptoms which he may erroneously regard as primarily due to the direct effect of the anæsthetic upon the circulation.

Sir Joseph Lister has pointed out that respiration may become noiselessly obstructed under chloroform. When the stage of excitement and struggling is well marked, as it frequently is in alcoholic, extremely sensitive, or vigorous subjects, the heart's action may be interfered with by reason of the respiratory embarrassment. Spasm of the respiratory muscles, by suspending thoracic movement and causing diminished blood oxygenation, leads to a retardation of the pulmonary circulation, and consequently to an over-distended state of the right heart;[2] whilst general muscular spasm adds to this distension by increasing the influx of venous blood. We are all familiar with the external manifestations of this venous engorgement during the period immediately preceding surgical anæsthesia. Several cases have been recorded in which syncope unquestionably arose in connection with excitement and struggling under chloroform.[1] The more vigorous the circulation, and the lighter the anæsthesia at the time, the longer will the heart stand out against the strain. A feeble, fatty, or dilated heart, more especially if the patient should be in the sitting posture, may readily fail during a comparatively minor degree of respiratory embarrassment.

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[1] MM. Sedillot and Claude Bernard especially drew attention to the danger of asphyxial symptoms during the administration of chloroform, and pointed out that such symptoms were liable to be rapidly followed by syncope. (See *Lancet*, April 17, 1875, p. 549.)

[2] See 'An Essay on Asphyxia,' by Sir George Johnson, F.R.S. See also *Lancet*, vol. i. 1891, pp. 760 and 814.

(*d.*) The **surgical procedure** for which chloroform is administered may, of itself, produce all grades of cardiac failure. There seems to be a greater tendency to this complication under chloroform than under nitrous oxide or ether; and there is ample ground for the belief that it is more liable to arise during a light or moderately deep, than during a very profound anæsthesia. (See Illustrative Cases, No. 38, p. 318; No. 39, p. 319; No. 40, p. 320; and No. 41, p. 321.)

The entry of air into veins during surgical operations has been regarded by many writers as responsible for numerous cases of fatal syncope during anæsthesia. But it is questionable whether the symptoms which have been attributed to this occurrence have not in reality been due to other conditions.[2]

4. The Passage of Foreign Bodies (Blood, Vomited Matters, &c.) into the Larynx and Trachea.—For remarks on this subject the reader is referred to Part III., Chap. II. p. 286.

5. Other Dangers.—These will be considered below (E. After-Effects, p. 235).

D. THE DEPTH OF ANÆSTHESIA NECESSARY FOR SURGICAL OPERATIONS.

We can readily understand the discrepancies of opinion concerning the effects produced by chloroform, when we reflect that administrators of large experience differ widely as to the degree of anæsthesia which they consider to be appropriate for surgical operations. One chloroformist will work with a light anæsthesia; another with a moderately deep anæsthesia; and another with a very deep anæsthesia. The success of Syme in administering chloroform appears to have been principally due to the almost invariable maintenance of a profound narcosis. From what has been already said, the reader will have gathered that the surest way to avoid irregular and hampered breathing (which is liable to be followed by circulatory depression) is to work with that depth of anæsthesia in which such alterations in respirations are impossible. The lighter the anæsthesia, the more liable will the patient be to respiratory and circulatory changes of an inconvenient, and possibly dangerous nature. In the early days of chloroform, patients were rarely thoroughly narcotised. Struggling, tonic spasm, holding the breath, retching, vomiting, and other symptoms of imperfect anæsthesia were the rule, rather than the exception. The patient was usually placed moderately deeply under chloroform; the operation quickly performed; and in many, if not in most cases, no more of the anæsthetic was administered. In those operations which could not be thus rapidly completed, the patient was allowed to become nearly conscious before more chloroform was given. Simpson, Syme, and Lister have, in their turn, drawn attention to the importance of a more free and uniform exhibition of this agent; and the profession is greatly indebted to these observers for their emphatic teaching. If chloroform is to be given at all, it must not be given too sparingly. But, as has been before pointed out, the maintenance of a profound narcosis reduces the workable area under chloroform to somewhat narrow limits. In other words, if we wish on the one hand to avoid the dangers of a light anæsthesia, and on the other to keep away from the phenomena of an over-dose, we shall find our task by no means so easy as is often supposed.

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[1] See my paper in vol. lxxiv. of the *Trans. Roy. Med. Chir. Soc.*, p. 107, in which numerous cases are referred to.

[2] The reader is referred to an interesting and original paper by Dr. H. A. Hare of Pennsylvania, on 'The Effect of the Entry of Air into the Circulation' (*Therapeutic Gazette*, 3rd ser., vol. v. p. 606). Dr. Hare found by numerous experiments that, unless air was introduced in *very large quantities* into the veins of the lower animals, no serious results could be produced. It should be mentioned, however, that the dogs which he used were either experimented upon without any anæsthetic or were under *ether*, not chloroform.

Most of that which has already been said with reference to the maintenance of a right degree of ether anæsthesia will apply to chloroform; but there are some differences in the two cases which are of considerable importance.

As in the case of ether, the anæsthetist, having once secured a satisfactory form of anæsthesia, must be guided by—

(*a.*) The respiration;
(*b.*) The occurrence of swallowing movements;
(*c.*) The lid-reflex; and
(*d.*) The state of the eye and pupil.

But in addition to these guides, experience teaches us that it is necessary to frequently consult—

(*e.*) The strength and frequency of the pulse; and
(*f.*) The colour of the face and lips.

Finally, cases occasionally occur in which

(*g.*) Rigidity of the muscles in various parts of the body (hands, neck, &c.)

may help the administrator in deciding as to the proper level at which he should keep his patient.

(*a.*) If one symptom, and one symptom only, is to be taken as a guide during chloroform administration, the **respiration** should undoubtedly be selected. When once a softly snoring form of breathing has been secured, an endeavour should be made to maintain it. The withdrawal of the anæsthetic will lead to tranquil and inaudible respiration; whilst an increased quantity of chloroform will, in most cases, favour the continuance of (or even augment) the existing stertor. I say *in most cases*, because it is sometimes impossible to obtain this desirable state of respiration; and the administrator may be in doubt as to the depth of the narcosis. Should the breathing be inaudible, the administrator may usually cause a softly snoring sound to manifest itself by gently pressing the lower jaw backwards; and this artificially produced stertor will often act as a good guide. Owing to the tendency for tranquil respiration to occur under chloroform, even when an insensitive conjunctiva, a moderately contracted pupil, and muscular flaccidity are present to testify to the establishment of deep anæsthesia, the administrator will not infrequently be in a state of doubt as to the degree of narcosis, if he relies solely on the respiration. He will not know whether the quiet breathing indicates a too light or a too deep anæsthesia; and in the absence of other indications he may therefore erroneously administer too much or too little of the anæsthetic, as the case may be. Fortunately other guides come to the rescue, and by the assistance of an act of deglutition, a smaller pupil, slight lid-reflex, an expiratory noise, or a tendency towards tonic muscular spasm, the administrator becomes aware that the tranquil respiration is indicative of too light an anæsthesia. As a general rule we may say that—

Inaudible breathing,
A good colour,
A moderately contracted or contracted pupil, and
A slight degree of lid-reflex,

collectively indicate the need for more of the anæsthetic; and, as the result of increasing the quantity of chloroform, respiration will quickly become audible and deeper. If the patient should have been allowed to come so far out of a deep anæsthesia that the inaudible breathing is associated with pallor, feeble pulse, and other indications of approaching vomiting, it may be difficult, or even impossible, to secure a deeper and noisier breathing till the vomiting has taken place.

A very deep chloroform anæsthesia is not infrequently associated with a somewhat shallow and hampered form of breathing; but this, if carefully watched, does not seem to be fraught with any great danger. It may indeed be necessary in certain cases, and in certain subjects, to proceed to this degree, in order to avoid reflex difficulties. The breathing in question is usually associated with the absence of lid-reflex, slight duskiness of the features, and a rather slow regular pulse, which, although not as full as in a less profound anæsthesia, is not markedly feeble. When the patient has passed into this condition the administrator will find that by briskly rubbing the face and lips[1] with a dry towel he can generally maintain efficient respiration, and consequently a better pulse and colour.

High-pitched crowing breathing (inspiratory) is of considerable interest in connection with the administration of chloroform. Generally speaking, profound anæsthesia prevents its occurrence. In certain operations, however, it is practically impossible to obviate the laryngeal stridor, even by very large doses. Should it tend to culminate in total cessation of breathing, an increase in the quantity of chloroform will usually avert the difficulty; but this, as already mentioned (p. 222), is not always the case.

The manner in which expiration is performed will often assist the administrator, and I cannot do better than quote from Dr. Sheppard's notes, in which I find the following interesting remarks:—

> "It would be useful and of practical importance to get at the exact series of signs connected with the expirations, as they are of great use in the conduct of many cases. They seem to occur pretty regularly in the following order, as the patient emerges from the deep regular breathing of chloroform narcosis. (1.) Slight holding of the breath before the commencement of expiration, soon developing a definite catch. (2.) The expiratory catch becoming definitely vocal, but only occurring at the commencement of expiration. (3.) Definite expiratory phonation, the vocalisation continuing all through the expiration, or it may still retain the character of (2.), and develop into straining. (4.) Movements of tongue and lips, &c., producing inarticulate mumbling. (5.) Definite articulate phonation."

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[1] Mr. Meredith, of the Samaritan Hospital, informs me that he used to find this little procedure of great value in the administration of chloroform for abdominal section. The late Dr. C. E. Sheppard also found it of advantage. In consequence of the recommendations of Mr. Meredith and Dr. Sheppard I have frequently resorted to brisk friction of the lips and cheeks when any tendency towards feeble respiration or circulation has arisen under chloroform; and always with good results. I have often been surprised at the immediate improvement. I have known almost imperceptible breathing to quickly become deeper and more audible, and have observed this change to be at once followed by a better pulse and colour.

(*b.*) All that has been said with regard to the occurrence of **swallowing movements** under ether will apply in the present instance (p. 165).

(*c.*) The **lid-reflex** under chloroform appears to be of less value as a guide than in the case of ether. I have frequently known patients under the former anæsthetic to be wanting in all traces of this phenomenon, and yet to be liable to swallowing, coughing, and vomiting; whilst, on the other hand, cases frequently occur in which a somewhat brisk lid-reflex may be witnessed in association with unmistakable signs of a proper degree of chloroformisation. In order to understand these apparent anomalies certain facts must be borne in mind. In the first place, there can be no doubt that this reflex should be absent at the moment when the operation is commenced; but other signs of profound anæsthesia should also be present, lest the administrator be deceived. In robust patients undergoing operations upon sensitive parts, the lid-reflex should, as a general rule, be kept in abeyance throughout. Old people, feeble subjects, and those who have lost much blood, or have become otherwise exhausted by the operation, may usually be allowed to exhibit lid-reflex occasionally. I am convinced that it is frequently necessary to maintain a deeper anæsthesia than that present at the moment when the lid-reflex disappears; but the administrator can only decide this point by taking into account the general physique of his patient, the nature of the operation, and the behaviour of the circulation and respiration during profound anæsthesia. There are certain operations which are better performed during a moderately deep anæsthesia, such, for example, as those for the removal of tonsils or nasal polypi; and in such cases it is best not to abolish the lid-reflex save for a few seconds at a time. Some authors have stated that no danger can arise under chloroform so long as the lid-reflex is present; but this doctrine is certainly erroneous, and is liable to lead to serious results if applied to cases in which a light anæsthesia would involve respiratory embarrassment. (See Illustrative Case, No. 29, p. 294.)

(*d.*) Most of what has been said concerning the value of the **eye and pupil** as guides to the degree of ether anæsthesia will apply to chloroform. As already mentioned, the average chloroform pupil is smaller than the average ether pupil. Like the latter it is most useful when other signs are equivocal; as, for example, when the breathing is shallow and the lid-reflex absent. Moreover, when from the nature of the operation the breathing is deprived of its usual characters, variations in the size of the pupil in response to more or less of the anæsthetic may be very significant.

The following table will show the size of the pupil in 23 administrations, the operation being in progress at the time the size was recorded :—

Cases showing the Size of the Pupil during Deep Chloroform Anæsthesia; Operation Proceeding.

No.	Patient.	Operation.	Size of Pupil.
1	F. 23. Healthy.	Ovariotomy.	● (5½ mm.)
2	Average middle-aged man.	Radical cure of hernia.	● to ● (3 to 3½ mm.)
3	Stout middle-aged woman.	Amputation of breast.	● (2½ mm.)
4	Well-built young man.	Radical cure of hernia.	● (2½ mm.)
5	Child, 1½ or 2 years. Thin and pale.	Abdominal section.	● (2½ mm.). 15 min. elapsed before the pupils settled down to this size.
6	M. 51. Average height and build.	Operation on clavicle.	● to ● (2½ to 3 mm.)
7	M. about 55. Spare and of average height.	Tying lingual arteries before excision of tongue.	● to ● (1½ to 2 mm.)
8	M. 3. Strumous. Florid.	Spinal abscess.	● (2½ mm.)
9	Child of 2 years. Fairly nourished.	Radical cure of hernia.	● to ● (1½ to 2 mm.)
10	F. 16. Healthy looking.	Glands in neck.	● (4½ mm.) Probably partly reflex.
11	F. 74. Thin.	Malignant growth of umbilicus. Abdominal exploration.	● (2 mm.)
12	F. 65. Florid, alcoholic, and a little bronchitic.	Amputation of breast.	● to ● (2½ to 3 mm.)
13	F. 16. Well developed and florid.	Cervical glands.	● (3 mm.) A less deep anæsthesia made pupils larger (reflex). Compare with Case 10.

Cases showing the Size of the Pupil during Deep Chloroform Anæsthesia; Operation Proceeding (continued).

14	Child 3 years.[1]	For fæcal fistula in anterior abdominal wall.	● (4½ mm.) Deep anæsthesia.
15	F. 24. Average.	Cervical glands.	● to ● (4 to 4½ mm.) Deep anæsthesia.
16	F. 42. Chronic bronchitis.	Abdominal section.	● to ● (2 to 3 mm.)
17	M. 65. Well built, tall, slight bronchitis, heart's action irregular.	Abdominal section for obstructive jaundice.	● (2½ mm.)
18	F. 47. Very emaciated.	For chronic intestinal obstruction.	● (2½ mm.)
19	M 22. Well built.	Operation on vermiform appendix.	● to ● (2½ to 3 mm.)
20	F. 19. Tall. Healthy looking.	Cervical glands.	● (3 mm.)
21	F. 42. Average.	Abdominal section.	● (5 mm.) Probably reflex.
22	F. 15. Healthy looking.	Cervical glands.	● to ● (2½ to 3 mm.)
23	F. 6. Healthy looking child.	Cleft palate.	● to ● (2 to 5 mm.) As a rule ● (3 mm.)

From this table it will appear that the commonest size was 2½ mm., and that the next commonest was 2½ to 3 mm., whilst operations were being performed during deep anæsthesia. The following extract from Dr. Sheppard's notes is worth quoting in this connection :—

"The dilated pupil is an excellent guide as an indication of returning consciousness, but one must be *very certain* that the patient is recovering and not actually becoming more deeply narcotised. . . . On administering a fresh dose, 5 to 10 minims, of chloroform to a child with the dilated pupil of recovery, the effect is *not immediate*, but after five or six inspirations after cessation of chloroform, the pupil becomes contracted. The postponed operation of chloroform is better seen in this way than in any other. Hence the danger of even 5 minims to a child with the dilated pupil of deep narcosis."

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[1] This child was anæsthetised by my friend the late Dr. Sheppard, at the Middlesex Hospital, and I took notes of the case.

Speaking generally, a dilated pupil *plus* conjunctival reflex calls for more chloroform; whereas a dilated pupil *minus* conjunctival reflex should be taken to mean immediate withdrawal of the anæsthetic till the pupil has become smaller, or the conjunctiva slightly sensitive.

(*e.*) Those who maintain that the **pulse** should be disregarded during chloroformisation will be far more likely than others to occasionally overstep the boundaries of safety.[1] Whilst every one must admit that the continuous observation of the pulse is unnecessary, and in many cases is liable to mislead, there can be no doubt that, when any uncertainty exists as to the general condition of the patient, the pulse will often be of great service. Like the pupil, the pulse is of value as a corroborative landmark. When all the signs of deep anæsthesia are present, a marked slowing of the pulse may, for example, indicate that the anæsthetic should be withdrawn for a while. In rare cases it is impossible to proceed beyond a certain point without inducing an intermittent action of the heart; and such cases must be similarly treated.

In drawing conclusions from the pulse, we must bear in mind that its force under chloroform is noticeably dependent upon the efficiency and amplitude of the respiratory movements. Other things being equal, the better the respiration the better will be the pulse. As deep respiration is usually the result of a deep anæsthesia, and *vice versâ*, it follows that the pulse may improve by giving more of the anæsthetic.

The administrator should occasionally consult the temporal, facial, or superior coronary pulse. If he can feel a fair pulse in either of the two former arteries, he may depend upon the wrist-pulse being better than he anticipates. I have often been unable to distinguish a temporal pulse, although the radial was at the moment of fair volume. I find the superior coronary pulse, which is readily felt on the inside of the upper lip, to be very accessible during chloroform administration.

(*f.*) **The colour of the face and lips** can hardly fail to be observed, except perhaps during certain operations upon or near these parts. It is a mistake to suppose that the approach of danger may be invariably detected by alteration of colour; cases having been reported in which considerable cardiac depression existed without a marked change. Cyanosis indicates that, though cardiac action is proceeding satisfactorily, deficient aeration is present; and more air should be admitted. Pallor occurring during a light anæsthesia generally means the approach of vomiting. The administrator should endeavour to maintain a good colour throughout. He is most likely to succeed in this by keeping up a deep anæsthesia, which, as we have seen, is favourable to deep respiration and good circulation.

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[1] Mr. J. Mills, who has had a large experience in the administration of anæsthetics (*Lancet*, vol. ii. 1880, p. 912), directs attention to the advantages of watching the pulse during the administration of chloroform, and quotes three cases illustrating this point.

E. AFTER-EFFECTS.

After the withdrawal of the anæsthetic the respiration will gradually become quieter, and probably inaudible. Conjunctival reflex will become re-established. The pupils will regain their mobility, and will either grow larger or smaller than they were. Dilatation commonly, though not invariably, occurs when vomiting is about to take place. Contraction is prone to ensue when the patient is left wholly undisturbed.

The rapidity with which such signs of returning consciousness appear will vary not only with the quantity of anæsthetic inhaled, but with other circumstances which need not now concern us.

The after-effects of chloroform differ considerably in different cases; and we are still to a great extent in the dark as to the factors which come into play in their production. The patient who has been kept deeply and properly anæsthetised will usually make a very satisfactory recovery, provided that there is no mechanical interference with the elimination of the anæsthetic. The cough or act of retching, at the termination of the administration, will bring back a good colour to his face and lips, and if left to himself he will probably pass into a quiet sleep. When inadequate quantities of the anæsthetic have been given, so that the patient's respiration has been more or less hampered over a considerable period by swallowing, coughing, straining, vomiting, &c., recovery from the effects of chloroform is not so satisfactory. Pallor is more common; and the pulse may remain feeble for a considerable time. A similarly unsatisfactory recovery is also common when dangerous symptoms have manifested themselves during the inhalation, and have required such treatment as the application of the tongue forceps, or artificial respiration.

Transient **nausea, retching, and vomiting** are not as frequent after chloroform as after ether; but troublesome and distressing vomiting is certainly more common in the case of chloroform. The almost characteristic retching immediately after etherisation has been fully discussed (p. 168). Owing to the smaller quantities of mucus secreted under chloroform, coughing and straining are not so frequently witnessed as immediately after the withdrawal of ether. This has led many to think unfavourably of ether in this respect. But we ought hardly to reckon the transient ether-retching as in any way inconvenient: it very soon passes off. When vomiting comes on after chloroform, it is far more likely to prove distressing to the patient, and intractable to treatment.[1] Ether-vomiting is like ether-hæmorrhage—brisk at the time, but unlikely to recur. Chloroform nausea and retching often persist after the stomach has ejected its contents [2] (supposing food, mucus, &c., to have been present [3]).

There appears to be little or no risk of subsequent **œdema or catarrh of the bronchi or lungs** after chloroform—at all events no risk attributable to the anæsthetic. Patients have not infrequently been attacked, however, by fatal bronchitis after chloroformisation, but an open window, or prolonged exposure of the chest, has usually been to blame, and not the chloroform.

Transitory **mental and muscular excitement**, similar to that referred to when dealing with the after-effects of ether, may occur in hysterical and neurotic subjects. **Delirium** lasting three days has been recorded.[4] **Loss of speech** [5] (attributed to cerebral hæmorrhage) has also supervened after chloroformisation. Persons who have had **maniacal attacks** before the administration of chloroform, have been known to suffer from a recurrence of their mental disorder after the use of this anæsthetic.[6]

Although **albuminuria** has been described as ensuing upon chloroformisation, there is no definite evidence to support the view that the anæsthetic was the cause of the symptom.[7] **Glycosuria** is also stated to have been met with after chloroform.

In very exceptional cases **jaundice** has been induced by the use of chloroform.[8]

Lastly, it has been alleged that the frequent inhalation of chloroform has in some cases been followed by **degenerative** changes in the heart and other parts of the body; but further data are necessary before we can accept any such statement.[1]

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[1] Snow refers to a case in which vomiting after chloroform proved fatal; and others have, I believe, occurred.

[2] This is pointed out by Mr. Marcus Gunn (*Brit. Med. Journ.*, Sept. 19, 1885).

[3] Snow and Clover reckoned that vomiting took place in 1 out of 7 cases. They probably refer to severe cases only—not to transient vomiting. Mr. Rigden (see foot-note, p. 169) found vomiting to occur in 32.86 per cent. of his cases, and of these it was noted as troublesome in 16.17 per cent.

[4] See an interesting pamphlet, 'Ether as an Anæsthetic,' by Josiah de Zouche, M.D., of Otago, in which delirium lasting three days in a boy of 14 was met with after chloroform-inhalation.

[5] *Lancet*, vol. i. 1870, p. 553. Chloroform was given for a tooth extraction. The aphasia lasted five weeks.

[6] See Savage, *Brit. Med. Journ.*, Dec. 3, 1887, p. 1199.

[7] See Kappeler.

[8] Murchison, 'Diseases of the Liver,' 2nd edition, p. 407.

F. ILLUSTRATIVE CASES.

The following cases will illustrate many of the points to which reference has been made in the preceding portions of this chapter.

It may be well, in the first place, to quote a couple of normal cases.

Illustrative Case, No. 11.—F., æt. 19. Tall: well developed: has a flabby appearance, especially about lower part of face: full lips: no thoracic abnormality discoverable. Removal of caseous cervical glands. Administration lasted one hour. Skinner's inhaler. Breath held a little at first. No excitement or struggling. Respiration became gradually deeper and rougher. After 5–6 min. colour good, respiration regular and rough, pulse good and rather slow, pupils ● (=3 mm.), conjunctiva barely sensitive. Operation commenced. No reflex movement. Respiration continuing satisfactory, a slight lid-reflex was permitted, but if this reflex became at all marked more chloroform was given. Less chloroform allowed the breathing to become quieter, the pupils smaller, and the lid-reflex more marked. More chloroform had exactly opposite effects. After stitches had been put in, and the anæsthetic withdrawn, the pupils enlarged, and the conjunctiva became very sensitive. In a second or two retching commenced, and a little mucus was ejected. Pupils then gradually got smaller.

Illustrative Case, No. 12.—Florid, intelligent girl, æt. 16: average height, and slim build: pupils ● (= 4½ mm.). Removal of glands from neck. Administration lasted 46 min. Skinner's inhaler.

2. 5 P.M. Administration commenced.
2. 9 " Muttering and swallowing.
2.11 " Pupils ● (= 4 mm.).
2.12 " Ready for operation. Pupils ● to ● (= 3–3½ mm.). Snoring regular breathing. No movement with incision, but pupils went to ● (4 mm.).
2.14 " Less stertor. More chloroform. Stertor more marked and pupils ● (=5 mm.) No lid-reflex. Very good colour and pulse.
2.16 " Pupils as before. Less chloroform seemed to make pupils, if anything, larger.
2.19 " Pupils still 5 mm: doubtfully active to light. Florid colour.
2.20 " An act of deglutition. Pupils ● (=4 mm.) with lid-reflex. Increased quantity of chloroform now produces larger pupil.

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[1] See Ungar, *Brit. Med. Journ.*, Jan. 14, 1888, p. 91.

2.23 P.M. A slight cough. Pupils ● (=4½ mm.). Increased the chloroform. Cough subdued. Slight crowing with inspiration. Chloroform again increased to subdue it. Pupils ● (=5 mm.). No lid-reflex. Pulse good and regular, about 75.

2.28 ,, Whilst glands being removed from neighbourhood of carotid and jugular the respiration became shallow, and pulse a trifle less full. This shallow respiration lasted 2–3 min. Lips briskly rubbed with good result. Pupils ● (=4½ mm.). No lid-reflex.

2.32 ,, Respiration stertorous and deeper again. Good pulse: doubtful lid-reflex.

2.35 ,, Pupils ● (=3½ mm.). No lid-reflex. A little moaning with expiration, and less stertor. Chloroform increased, and with result of deeper stertor and larger pupil. (Obvious influence of more chloroform in causing a larger pupil.)

2.36 ,, Slight cough and crowing breathing. Anæsthetic increased.

2.38 ,, Pulse very good.

2.41 ,, Pupils ● (4 mm.). Doubtful lid-reflex. Administration continued. Pupils ● (4½ mm.).

2.42 ,, Quieter respiration. Slight expiratory moan suggestive of impending cough, and pupils became ● (=3½ mm.). Stitches now put in, and pupils at once dilated to ● (=5 mm.).

2.51 ,, Administration discontinued.

In the following case, which I take from Dr. Sheppard's notes, aortic and mitral disease was present.

Illustrative Case, No. 13.—F., æt. 35. Aortic and mitral disease. Ovariotomy. Worked almost entirely by the pupil, and phonation occurring during expiration. The following was the sequence:—

(*a*) Contracted pupil,
Conjunctival reflex present,
Expiratory phonation:
Then (*b*) Pupil gradually dilated,
Conjunctival reflex abolished,
Slight expiratory phonation:
Then (*c*) Dilated and fixed pupil, and
Cessation of phonation.

About m.xv. of chloroform took the patient through all these stages; and the recovery back to contracted pupil took, roughly, a minute or so. Laryngeal musical stertor present all through, and not much affected by position of head or pulling jaw forwards. Pulse good all through, and patient came well and quickly out of the narcosis.

The administration of chloroform to a patient suffering from dyspnœa due to an enlarged thyroid is exemplified in the following case. As the dyspnœa did not increase under the anæsthetic, but actually diminished, it was probably the outcome of laryngeal spasm rather than of pressure upon the trachea.

Illustrative Case, No. 14.—M., æt. 17. Tall: slim: full lips: rather nervous. Occasional distress in breathing. Prefers to be propped up somewhat. Dry sounds throughout both lungs. Occasional moist cough. Audible stridor on taking a deep breath. Large thyroid growth. Operation 10 A.M.: dry, bright, cold morning. Chloroform on lint. Administration, 1 hour 13 minutes; operation, 1 hour 5 minutes. Two ozs. of chloroform used. Head and shoulders slightly raised. Anæsthetic cautiously given. Barely audible breathing became audible (both inspiration and expiration). Thought it best, as breathing seemed to be getting rather laboured, not to push anæsthetic. Long incision. Very slight reflex movement, and deeper breathing. Occasional swallowing. Rather free hæmorrhage. Breathing grew quieter, *although no part of growth yet removed.* Thyroid now removed. Pulse got slightly feeble during extraction of left lobe, which was deeply seated; it then improved. Conjunctival reflex often present, with large ● (= 5 mm.) pupil; more chloroform abolished reflex and made pupil smaller ● or ● (3 or 2½ mm.). Pupils hence good guide. Face rather pale. No movement throughout. During removal of left lobe, transient inspiratory stridor of high pitch, but no cyanosis. No flattening of trachea discovered.

The following case seems to indicate that the presence or absence of the lid-reflex may be dependent upon the nature of the operation in progress:—

Illustrative Case, No. 15.—F., æt. about 50. Febrile. Of spare build. Heart-sounds and chest expansion good. Exploration and evacuation of a tubercular kidney. Skinner's mask. Administration lasted 1 hour 20 minutes. An abdominal incision was first made, and subsequently a lumbar opening. After about one hour the patient's condition was as follows, the operator working at the lumbar opening:—Pupils contracted: lid-reflex either completely absent or only present in the slightest degree: pulse good, regular, about 72: respiration quiet. The operator now passed in sponges through the abdominal wound, with the *immediate* result that the breathing became deep, the colour more florid, and so much lid-reflex appeared that the lids tightly contracted when the conjunctiva was touched. We might say that this patient was, at the moment referred to, sufficiently anæsthetised for the lumbar operation, but not for the abdominal. The interest of the case, however, lies in the re-appearance of the lid-reflex as the direct result of a particular stimulus, namely, interference with the peritoneum.

CHAPTER V.

MECHANICAL MIXTURES CONTAINING CHLOROFORM.

'BICHLORIDE OF METHYLENE.'

Mixtures consisting of chloroform with alcohol, chloroform with ether, and chloroform with alcohol and ether, have been very extensively employed for anæsthetic purposes, not only in this country but upon the Continent. The object in adding alcohol and ether to chloroform has been, not only to prevent too concentrated a chloroform vapour from being respired, but to counteract any tendency to circulatory depression which might be occasioned by the use of chloroform. By mixing a small quantity of alcohol with chloroform it is certainly possible to administer a chloroform vapour considerably weaker than that which would result were the undiluted agent administered in precisely the same manner: whilst mixtures of ether and chloroform have been shown, by comparative experiments, to produce a better cardiac action than chloroform alone.[1] There is, however, a formidable objection to these mechanical mixtures, and one which Snow particularly laid stress upon. It is that as the constituents have their own special rates of evaporation, the more volatile ingredients are first vapourised, the less volatile remaining to be subsequently respired. Ether is, for example, much more volatile than chloroform; so that if a mixture containing, let us say, equal parts by measure of these anæsthetics be administered, the vapour would at first be very rich in ether, and comparatively poor in chloroform; whereas, subsequently, the reverse would obtain. Ellis[2] overcame this objection by devising an apparatus which contained the anæsthetics separately, and their vapours were mixed in the desired proportions during the administration. The plan was very ingenious, but too complicated for general use. There is another way, however, in which the objection above referred to may, to a great extent, be overcome, at all events in the case of certain mixtures, viz., by employing such proportions of the liquid constituents as will evaporate in the same period of time at the same temperature. When it is impossible to adjust the proportions in this manner, the anæsthetist must administer small quantities of the mixture at a time, and frequently replenish the mask or inhaler, thus endeavouring, as far as possible, to get rid of one dose before another is added. Although Snow was not favourably disposed towards anæsthetic mixtures, Clover appears to have used certain of them with success. The latter[1] took advantage of the stimulant effect of ether by mixing 4–8 minims with 30 minims of chloroform in 1000 cubic inches of air in his chloroform apparatus, and found that he obtained a better pulse than with chloroform alone. When fatty degeneration of the heart was supposed to exist he advised and employed a mixture of chloroform and ether, containing one-sixth of the latter agent. He also used the A. C. E. mixture, and believed it to be specially appropriate when moderate narcosis was required for a long time. Various administrators since the time of Snow and Clover have also eulogised anæsthetic mixtures, especially for certain cases. But although these mixtures possess their advantages, they require special care in their use. They must not be looked upon as definite bodies capable of producing definite and characteristic phenomena, but rather as mixtures capable of producing mixed symptoms, dependent upon the physiological actions of the constituent anæsthetics, and upon the proportions in which those anæsthetics are present in the mixture used.

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[1] *Trans. Roy. Med. Chir. Soc.*, vol. xxix. 1864, p. 342.

[2] *Medical Times and Gazette*, vol. i. 1867, p. 246.

A. MIXTURES OF CHLOROFORM WITH ETHYLIC ALCOHOL.

Sansom[2] recommended and used **equal parts of chloroform and alcohol**, and believed that the good effects he obtained were due to the alcohol restraining the volatility of the chloroform, and thus preventing too concentrated a vapour. Others have employed this mixture with success.[3] When alcohol is used with chloroform it is, however, generally added in smaller proportions, *i.e.*, the chloroform is diluted with **one-fourth or one-fifth of alcohol**. I have in a number of cases used chloroform thus diluted, and with good results. The dilution is especially valuable when, as in the case of infants, young children, and feeble subjects generally, a very mild chloroform vapour is needed. If one-fifth of alcohol be added to chloroform, and the mixture be administered by means of a Junker's inhaler, it will be found difficult to anæsthetise vigorous or alcoholic subjects, although more susceptible patients will be readily affected.

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[1] *British Medical Journal*, February 14, 1874.

[2] *Medical Times and Gazette*, vol. ii. 1870, p. 107.

[3] See Stephens, *British Medical Journal*, January 1888, p. 19.

Mixtures of alcohol and chloroform should be **administered** in precisely the same manner as the undiluted anæsthetic.

B. MIXTURES OF CHLOROFORM WITH ETHER.

A mixture consisting of **one part of chloroform and two parts of ether** was examined and used by the Committee of the Royal Medical and Chirurgical Society, who found it to be very similar in its action to the A. C. E. mixture referred to below. Ellis,[1] in his inquiries into anæsthetic mixtures, considered it very unreliable, as it parted with its ether rapidly, and with its chloroform very slowly. A death under its influence has been reported.[2]

A mixture containing **one part of chloroform and three parts of ether**, often known as **the Vienna mixture**, has been extensively used abroad, a large number of administrations having been recorded without a casualty. It has, however, been found by observers in this country to be uncertain and irregular in its action,[3] and is now rarely used.

A mixture consisting of **one part of chloroform and four parts of ether** was examined by the committee above mentioned, and was reported to be very similar in its action to ether itself.

Mixtures of chloroform and ether should be **administered** by means of an open inhaler, such as that represented in Fig. 26, p. 136, or Fig. 40, p. 190. Bag inhalers should not be employed. The greater the proportion of chloroform, the nearer should the mode of administration approach to that already described on p. 192. Should the proportions of the two anæsthetics be such that the ether will be liable to evaporate before the chloroform, care should be taken to add the mixture to the inhaler in small quantities at a time, and to change the sponge from time to time.

C. MIXTURES OF ALCOHOL, CHLOROFORM, AND ETHER.

1. The A. C. E. Mixture.—This valuable mixture consists of one part of alcohol, two parts of chloroform, and three parts of ether. It was originally suggested and used by Dr. George

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[1] *Medical Times and Gazette*, vol. i. 1867, p. 246.

[2] *Ibid.*, No. 849, p. 378.

[3] *Lancet*, vol. ii. 1872, p. 828.

Harley. Some years later the Committee of the Royal Medical and Chirurgical Society made a careful trial of it, and with very favourable results. They recommended it as preferable to chloroform; and this recommendation is to a great extent accountable for the present extensive employment of the mixture. According to the committee the specific gravities of the constituents should be—

Alcohol	.838
Chloroform	1.497
Ether	.735

Martindale states[1] that by employing—

Alcohol	sp. gr.	.795	1 part,
Chloroform	,,	1.497	2 parts,
Ether	,,	.720	3 parts,

he obtains a mixture which volatilises uniformly; and if this be so, the objection already alluded to, as common to most anæsthetic mixtures, will cease to exist in this particular case.[2]

Properties.—When freshly prepared from the purest ingredients (all kinds of methylated ether should be avoided), and when inhaled gradually and with plenty of air, the A. C. E. mixture possesses an agreeable, somewhat fruity odour, and is certainly as pleasant as, or even more pleasant than, chloroform itself. The mixture is more stable than is usually supposed, and it is quite possible that some chemical change, of which we are at present in ignorance, takes place when the alcohol, chloroform, and ether are mixed. I have noticed that perceptible heat is disengaged when the three constituents are mixed together and agitated; and the characteristic odour of ether is quickly lost after the bottle has been well shaken. There will be found to be, moreover, after the mixture has been made, a striking absence of that tendency which unmixed ether displays to become vapourised; in other words, by shaking the bottle or warming it by means of the hand, little or no increase of internal pressure, such as that which is immediately evident on removing the stopper of an ether bottle similarly treated, will be detected. The ether present in the mixture certainly does not show that inclination to rapid escape which it has been supposed to possess. The A. C. E. mixture should nevertheless be freshly prepared, and kept in small, tightly stoppered bottles.

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[1] 'Extra Pharmacopœia.'

[2] I have for several years used the A. C. E. mixture prepared by Messrs. Robbins & Co. I am informed by them that they use: Alcohol, sp. gr. .830; chloroform, sp. gr. 1.497; and ether, sp. gr. .720.

Administration.—In administering the A. C. E. mixture two cardinal points should be borne in mind—(1.) To give a plentiful supply of air with the vapour; and (2.) to employ small quantities (say ½ a drachm) at short intervals, in preference to placing a larger quantity (say 2 or 3 drachms) upon the inhaler at one time. I have found a drop bottle of the shape shown in Fig. 44, p. 192, but of larger size, to answer well. The inhaler used should be simple in construction. A Skinner's mask, or the corner of a towel drawn through a safety-pin may with advantage be employed to commence the inhalation, as closer forms of inhalers may cause discomfort to the patient. Children and weakly persons may be kept satisfactorily anæsthetised without any further apparatus; but in other subjects a Rendle's inhaler, a felt cone open at the apex, or a cone-shaped cloth similarly arranged for a free air supply may be needed. The air-holes in Rendle's inhaler (p. 136) are hardly large enough, so that it is best to have a portion of the leather (½ to 1 in. in diameter) cut away, to provide for a very free supply of air. If a Skinner's mask be used throughout, a considerable time may be taken in anæsthetising an average adult patient. If, however, the mask is kept more or less completely saturated, anæsthesia will result in from eight to ten minutes. Clover's and Ormsby's inhalers should not be used; nor is Junker's apparatus suitable, owing to the inconvenience of frequently replenishing it with small quantities of the mixtures.

Effects.—When the A. C. E. mixture is administered with the precautions already described, it produces effects which are, in their main features, similar to those met with when employing chloroform.[1] There are, however, as we should expect, certain obvious differences in the two cases. As the administration proceeds, respiration gradually becomes deeper and more audible, as with chloroform itself; but unless care be taken to avoid too strong a vapour, swallowing, holding the breath, and coughing will be more easily excited than with undiluted chloroform. There is somewhat more mucus and saliva produced than with the last-named anæsthetic; but not nearly so much as with ether. Any attempt at retching or vomiting must be met by carefully continuing the administration. Though it is difficult to speak positively on this point, I am inclined to believe that the stage of excitement is somewhat less pronounced under the mixture than under chloroform. The administrator should not attempt to get his patient ready for operation in too short a space of time: from five to eight minutes should usually be taken. Weakly persons and young children will yield more quickly to the anæsthetic than vigorous or alcoholic patients. Old persons, very fat subjects, middle-aged emphysematous and bronchitic subjects will often be found to take the A. C. E. mixture remarkably well, and to pass into quiet anæsthesia with little or no trouble. Stertorous, regular breathing, absence of lid-reflex, muscular flaccidity, a fixed state of the globes, and a moderately contracted pupil are the signs which should be looked for and maintained when quiet and profound anæsthesia is desired. As with chloroform and ether, the respiration should be kept softly snoring if possible. The breathing is, in fact, one of the best guides; any tendency to quiet respiration being probably due to too light a narcosis. When any doubt exists, however, as to the degree of anæsthesia present, other signs must be consulted. The lid-reflex and pupil are both good guides. The latter during deep anæsthesia is generally either the size of that already described as almost characteristic of chloroform anæsthesia, or is a trifle larger; but, as with all anæsthetics, variations not infrequently occur. I have notes of several cases, for example, in which it was necessary to maintain a pupil of or (= $3\frac{1}{2}$ or 4 mm.), any attempt to work with a pupil of or (= $2\frac{1}{2}$ or 3 mm.) being at once followed by signs of imperfect anæsthesia, such as rigidity, tendency to cough, &c. Should a dilated pupil be associated with distinct lid-reflex, more of the mixture may be given if desired; but should such a pupil exist with an insensitive cornea, the anæsthetic should be withheld until the pupil has become smaller, or the lid-reflex re-established. More should then be given in small quantities. Respiration during the use of the A. C. E. mixture is usually deeper than in the case of chloroform; but not so deep or so liable to temporary embarrassment as with ether. The colour of the features, too, is liable to be somewhat more dusky than with chloroform itself, probably because of the greater secretion of mucus and saliva. High-pitched crowing breathing must be carefully treated. As a general rule the anæsthetic should be withdrawn for a while and the lips briskly rubbed (p. 230), but if the condition be obviously associated with imperfect anæsthesia, as ascertained by other signs, the administration may be cautiously continued, being at once stopped if the crowing does not subside. The circulatory phenomena of a patient under the A. C. E. mixture are very similar in many respects to those observable in the case of chloroform. The pulse is, however, generally fuller and quicker than the chloroform pulse, and certainly less liable to become affected by those depressing influences which may come into play in chloroform narcosis proper. In infants and very young children, the proper degree of anæsthesia may be arrived at by observing the breathing, condition of the general muscular system, and the pupil. Very quiet breathing, a tendency to rigidity of the arms or legs, and a very small pupil point to a light anæsthesia. A few drops of the mixture will generally suffice to produce deeper breathing, relaxation of the muscles, and a moderately contracted or medium pupil.

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[1] The Hyderabad Commission state (*Lancet*, vol. i. 1890, p. 158) that this mixture gives the same tracings as chloroform alone.

The A. C. E. mixture is by many regarded as the best anæsthetic for routine use. For example, Mr. Moss, of King's College Hospital, writing to me in 1889, informed me that he had then employed it in over 10,000 cases, and with excellent results.[1] The cases in which, according to my own experience, the A. C. E. mixture is specially serviceable are considered on p. 72; whilst the special advantages which the mixture seems to possess as a preliminary anæsthetic before ether will be discussed in Chap. VI. of this Part.

The following illustrative cases are of interest as showing the value of the mixture in certain patients:—

Illustrative Case, No 16.—(This case occurred in the practice of my friend Mr. Marmaduke Sheild, to whom I am indebted for the following notes.) "Patient an engine-fitter, aged 42. A brawny, heavily-built man. Neck practically obliterated by an enormous swelling, reaching from the malar bones to the sternum, livid in colour, and hard and board-like to palpation. Much dyspnœa. Face livid and bedewed with sweat. Pulse weak and quick. Unable to speak or open mouth. Nitrous oxide had been given and an exploratory incision commenced; but the man had so nearly died that the operation was abandoned. It was obvious he was suffering from pressure upon the larynx and trachea. I ordered him to be given the A. C. E. mixture in a large cone with a plentiful supply of air. I further requested that the administration should be very gradual. It was quite ten minutes before slight rigidity and struggling took place. The patient seemed unconscious to pain, but was not completely flaccid. I made a free incision on the right side of the neck. The tissues did not bleed. The deep fascia was carefully incised, and I then passed my finger behind the carotid sheath into a large abscess cavity, from which a quantity of pus gushed out. The inspiration instantly became more free, but as there was still some difficulty I made a free incision in the middle line of the neck. Instantly the patient began to respire deeply and easily. The anæsthetic had been discontinued at the commencement of the operation, and consciousness was returning. The man was able to speak, though with a hoarse intonation, and he expressed his gratitude at his relief. The subsequent progress of the case was perfectly satisfactory."

Had this patient been placed very deeply under the anæsthetic, or had the close method of inhalation been adopted, respiration would in all probability have come to a standstill.[1]

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[1] See an interesting letter on the value of this mixture in *Brit. Med. Journ.*, vol. ii. 1880, p. 797.

The A. C. E. mixture is often of great use in patients in whom grave respiratory difficulties from other causes than tracheal narrowing are present. The following case, in which the breathing was embarrassed by the most extreme abdominal distension which I have ever witnessed, may be quoted :—

Illustrative Case, No. 17.—F., æt. 37. Thin, anxious face: slightly dusky complexion: very breathless and orthopnœic: hands cold: pulse quick and feeble: chest walls thin: abdomen enormously distended with ascitic fluid and large ovarian tumour: heart much pushed upwards. As the patient was sitting upright upon an operating-table I had to administer the anæsthetic standing upon a chair. Judged it best to work with two different stages of anæsthesia :—(1) Light anæsthesia during removal of ascitic fluid; and (2) deep anæsthesia during removal of tumour. Stage (1) conducted with A. C. E. mixture: ether tried, but not well borne. Several gallons of fluid evacuated gradually: patient analgesic rather than anæsthetic. One by one pillows removed as fluid evacuated. Breathing gradually improved. During stage (2) patient recumbent, and chloroform given on Skinner's mask. Pulse got rather weak, but improved with hot water flushing. Subsequently weaker again. Patient removed to bed.

In cases of peritonitis, intestinal obstruction, &c., with a fixed and inactive abdomen, and some respiratory difficulty, the A. C. E. mixture is perhaps the best anæsthetic. The following is an example :—

Illustrative Case, No. 18.—F., æt. about 19. Ill for one week with peritonitis. Abdomen distended. Slightly under morphine. Rather lethargic. Pulse fair and full, but compressible and quick. Colour good. Occasionally vomits blackish fluid. Abdominal section. Operation lasted half-an-hour. A. C. E. given on Skinner's mask. Took it well. After some minutes I changed to ether (Clover's inhaler), but this was not well borne, so went back to A. C. E. Kept her lightly under. Nearly all the time she was as follows :—Pupils ● (= 2 mm.): some conjunctival reflex, which was allowed to disappear for a few seconds at a time: respiration fairly regular, not stertorous, but deeper and quicker than before administration: colour good: pulse quicker and quicker, getting from about 90 to 120: right hand and arm moved occasionally. She vomited once on operating-table. Whilst intestine and ovary were being manipulated respiration grew quicker, and a kind of 'catch' in breathing was noted. No crowing respiration. After removal of anæsthetic colour not so good, though fair: hands warm: pulse quick: conjunctiva soon sensitive. Patient remained lethargic for some time.

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[1] An almost precisely similar case to the above is reported in the *Brit. Med. Journ.*, Oct. 29, 1892. Ether was used and the patient succumbed under its influence.

As already indicated (p. 72), the A. C. E. mixture is a valuable anæsthetic in most cases of advanced cardiac disease. It seems particularly useful when mitral stenosis is present. The three following cases occurred at the London Hospital, and I am indebted to Mr. W. Penberthy for the notes.

Illustrative Case, No. 19.—F., æt. 36. Mitral stenosis. Retro-uterine abscess. Operation lasted 20 minutes. A. C. E. on Skinner's mask. Went under readily, and easily kept under. Mask frequently removed for a breath or two. *The patient had formerly taken ether with a nearly fatal result.*[1]

Illustrative Case, No. 20.—F., æt. 24. Mitral stenosis. Perinæoraphy. Operation half-an-hour. A. C. E. given as in previous case with equally favourable result.

Illustrative Case, No. 21.—F., æt. 25. Mitral and aortic regurgitation. Operation on cervix uteri: 40 minutes. 13 dr. of A. C. E. mixture used on Skinner's mask. Result very good.

The A. C. E. mixture is also about the best anæsthetic I know for patients with advanced emphysema and bronchitis attended by fatty degeneration and dilatation of the heart. I quote the following case, as it was a particularly anxious one, so far as the anæsthetic was concerned. The question, in fact, had arisen as to whether it was advisable to give any anæsthetic at all. I selected the A. C. E. mixture, and fortunately it answered well.

Illustrative Case, No. 22.—M., æt. about 70: average build: looks 80. Half propped up in bed. Breathing rather hurried: expiration distinct and audible. Respiratory movements almost wholly diaphragmatic. Chest front hyper-resonant: wheezy sounds over it. Heart sounds 'flapping': an occasional murmur in apical region: much epigastric pulsation. Pulse very irregular and intermittent. Face congested: bluish red colour. He is subject to seizures of difficult breathing and cyanosis. Has a large prostate, and catheter has to be used every two hours. Operation supra-pubic cystotomy. Administration lasted 35 minutes. A. C. E. mixture. Gradually given on Skinner's mask. Respiration deeper and expiration more wheezy. No distress. Pulse improved, and became more regular and fuller; but never got quite regular. Face remained flushed. Some perspiration. Muttering. Conjunctiva still sensitive. Eyes commenced turning upwards. Then slight rigidity. No struggling. Catheter passed. Little if any reflex effect. Abdominal muscles tense, and respiration jerky. Distension of rectum by bag caused slight but not inconvenient movement. Skin incision also caused slight reflex movement, but absolutely no effect on wrist pulse. During most of administration his condition was as follows:—Conjunctiva just sensitive, once or twice insensitive: respiration wheezy, with noiseless inspiration and difficult expiration: pulse as before: pupils about ● (=4½ mm.). The hands gradually got chilly, and perspiration increased. No nausea or vomiting after.

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[1] An interesting case in which ether almost proved fatal in mitral stenosis is reported by Mr. Arthur Jefferson: *Lancet*, Sept. 20, 1884, p. 492. Chloroform was subsequently given with good result.

After-Effects.—The after-effects of the A. C. E. mixture are, in most cases, slight. It is, in my experience, quite the exception for a short inhalation (10–15 minutes) to be followed by anything but the most trifling discomfort. Old persons are rarely affected by after-sickness, even though the administration has lasted for a long time.

Dangers.—Several fatalities have occurred under the A. C. E. mixture. This is not to be wondered at when we reflect that the mixture is very extensively employed for anæsthetising patients whose general condition is extremely unfavourable. The mixture is often chosen for those who are considered unfit for chloroform on the one hand, and for ether on the other. Then, again, the erroneous practice exists of regarding this mixture as a stable and definite body, and of administering it in large doses seldom repeated, instead of in small doses often repeated. Furthermore, in some of the fatal cases[1] a bag-inhaler has been employed.

2. Other Mixtures.—Mixtures of alcohol, chloroform, and ether, containing these agents in somewhat different proportions to those of the A. C. E. mixture, have also been largely employed. **Billroth's mixture**, consisting of one part of alcohol, three of chloroform, and one of ether, is in great favour with many Continental surgeons. It is administered very much as chloroform is employed, and is said to be rarely followed by vomiting.

D. THE SO-CALLED 'BICHLORIDE OF METHYLENE' OR 'METHYLENE.'

Composition.—The so-called 'bichloride of methylene' or 'methylene' was brought before the notice of the profession in 1867 by Sir B. W. Richardson,[2] who gave it the formula CH_2Cl_2, and strongly recommended it for producing surgical anæsthesia. The 'methylene' supplied by Messrs. Robbins & Co. distils over at about 127°–128° F.,[3] and the temperature is stated not to vary more than 3° from first to last during distillation. As supplied by the manufacturers, 'methylene' is a colourless fluid, with an agreeable odour very similar to that of chloroform. Much discussion has taken place as to the precise chemical nature of 'methylene.' Whilst on the one hand Sir B. Richardson maintains that the drug sold under that name by the manufacturers is, with the exception that it contains traces of alcohol and water, chemically pure CH_2Cl_2, very strong evidence has been adduced to show that 'bichloride of methylene' is nothing more than a mechanical mixture of chloroform and methylic alcohol. The 'methylene' employed in a fatal case at Prague was carefully analysed by Professor Hofmeister,[1] who found it to be a mixture of chloroform diluted with one-fifth of methylic alcohol. This 'methylene,' which had come from the recognised London manufacturers, had a sp. gr. of 1.3495 at 17°.1 C. (68°.78 F.), commenced distilling at 47° C. (116°.60 F.), and continued between 49° C. and 53° C. (120°.2 F. and 127°.4 F.). One-fifth of the 'methylene' mixed readily with water, and gave the tests for alcohol. After separating the alcohol, the residue boiled at 59°.5–60°.5 C., and the distillate had a density of 1.4885 at 17°.1 C., and gave the usual tests for chloroform. As is well known, the boiling-point of a mixture of chloroform and alcohol is lower than that of either of its constituents, which accounts for the low boiling-point of the commercial 'methylene.' Moreover, MM. Regnauld and Villejean[2] prepared some chemically pure bichloride of methylene, and compared it with the anæsthetic fluid supplied by English makers under that name. They found that the standard pure bichloride of methylene had a sp. gr. of 1.334, and a boiling-point of 40°.4 C. (104°.7 F.). They further found that chemically pure CH_2Cl_2 produced epileptiform movements, jaw-spasm, and other untoward symptoms in the lower animals, so that its use in human beings could not but be fraught with danger. And, finally, they agree with Professor Hofmeister that the English 'bichloride of methylene' consists of chloroform and methylic alcohol. Dr. Junker[3] has, indeed, administered a mixture of chloroform and methylic alcohol (4 to 1) in several cases. The mixture had a sp. gr. of 1.281, and produced effects which appeared to him to be precisely similar to those observed with the so-called 'bichloride of methylene.'

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[1] See *Brit. Med. Journ.*, Oct. 24, 1891, p. 906.

[2] See *Asclepiad*, 1888, p. 201, 'Methylene as an Anæsthetic.'

[3] See *Brit. Med. Journ.*, vol. ii. 1883, p. 271.

Effects.—But whatever may be the chemical constitution of Richardson's 'methylene,' it certainly produces effects which deserve careful consideration from a clinical point of view. The first operation under its influence was performed by Sir Spencer Wells, who, after a very large experience,[4] still considers 'methylene' to be superior to all other agents. For several years after its introduction into practice, it was used somewhat extensively not only in this country but on the Continent. Its rapidity of action,[1] the speedy return to consciousness after its use, and the striking rarity of after-effects, rendered it specially serviceable in abdominal, ophthalmic, and dental operations. Dr. Day,[2] who has administered 'methylene' for Sir Spencer Wells and other surgeons in 1230 cases, most of which were cases of abdominal section, speaks in very high terms of the agent. He states that it is less likely than chloroform to cause vomiting; that it is more agreeable to inhale; that rarely more than 3 to 4 drachms are required for an operation lasting half-an-hour; that consciousness returns in a few seconds after inhalation is discontinued; that he has used it when serious heart and lung affections have existed, with good results; and, in fact, that, so far as his experience goes, 'methylene' is the best anæsthetic. Others speak in similarly favourable terms.[3] There are, however, two sides to every question; and many surgeons have tried 'methylene' and have discarded it. It enjoyed, for example, a long reign at the Samaritan Hospital, but was eventually replaced by its former rival chloroform. Nussbaum of Munich, who, in 1868, had administered 'methylene' 15,000[4] times without an accident, found its effects very similar to those of chloroform, but, according to Kappeler,[5] he met with considerable excitement, rigidity, and nausea in many cases. Hégar and Kaltenbach, who have largely used 'methylene' with Junker's inhaler, do not consider it safer than chloroform, but find less vomiting after its use than after chloroform. Kappeler endorses these views.

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[1] *Brit. Med. Journ.*, July 21, 1883.

[2] *Comptes Rendus de la Société de Biologie*, tom. i. 1884, p. 158. See also *Bull. Acad. Med.*, 2nd Sér., tom. xii. p. 568.

[3] *Brit. Med. Journ.*, vol. i. 1884, p. 451.

[4] See *Lancet*, vol. ii. 1890, p. 898, and vol. ii. 1877, p. 191.

Administration. — With regard to the administration of 'methylene,' Junker's apparatus (p. 194) has been found to be the best for the purpose. Rendle's[6] mask (p. 136) is used by some, but with this apparatus the danger of an over-dose, and of asphyxial troubles, is certainly greater than with Junker's inhaler. As the liquid is more volatile than chloroform, an open mask such as Skinner's is not applicable. The administration should be conducted as has been already described when considering chloroform (p. 198). Difficulty may be experienced in obtaining true surgical anæsthesia in some cases, especially when using Junker's inhaler. It must, therefore, be borne in mind that in operations upon very sensitive parts, and when dealing with patients who are not easily affected by anæsthetics, it may be necessary either to give more of the anæsthetic than can be administered by Junker's inhaler; that is to say, to use some other inhaler, or to change to ether, chloroform, or the A. C. E. mixture.[1]

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[1] I cannot agree with those who state that 'methylene' is a rapidly acting anæsthetic. It may quickly destroy consciousness when given in a somewhat concentrated vapour. But when administered by means of Junker's apparatus, ten, fifteen, or even twenty minutes may be required to induce anæsthesia. Indeed, not long ago, I met with a case in which I had to resort to another agent, as I was unable to secure tranquil and perfect anæsthesia with 'methylene.' The drug I used was freshly prepared. The patient was a tall, vascular, and powerfully-built woman of 60. After pumping with Junker's inhaler for about twenty minutes the patient was only partially anæsthetised. I then had recourse to the A. C. E. mixture, and in three minutes she was ready for operation.

[2] 'Methylene as an Anæsthetic' (*Brit. Med. Journ.*, July 14, 1888, p. 72).

[3] *Lancet*, vol. i. 1882, p. 371.

[4] *Med. Times and Gaz.*, vol. i. 1868, p. 111.

[5] 'Anæsthetica,' p. 105.

[6] *Brit. Med. Journ.*, vol. ii. 1880, p. 729.

Dangers.—Several deaths have occurred during the use of 'methylene';[2] the symptoms being almost identical with those which characterise chloroform fatalities. Inversion has been successfully tried in a case of threatened death.[3]

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[1] Two cases (rectal operations) are reported by Mr. Martin Coats, in which he found it necessary to replace 'methylene' by chloroform (see foot-note, p. 251).

[2] See *Lancet*, Oct. 23, 1869: *Brit. Med. Journ.*, May 7, 1870; April 29, 1871; Sept. 16, 1871; Aug. 31, 1872; Oct. 12, 1872; Oct. 19, 1873: *Lancet*, Dec. 2, 1874, p. 881: and *Brit. Med. Journ.*, July 24, 1875.

[3] *Lancet*, vol. ii. 1876, p. 462.

CHAPTER VI.

CHLOROFORM AND ITS MIXTURES FOLLOWED BY ETHER.

A. CHLOROFORM FOLLOWED BY ETHER.

From some points of view chloroform is a particularly appropriate anæsthetic to administer before ether. It is not unpleasant to inhale; its exhibition requires no complicated apparatus; and a very small quantity is needed to render the patient unconscious. Chloroform has, indeed, been largely used to precede ether. But we must not lose sight of the fact that most of the fatalities which have occurred during chloroformisation have occurred either at the very outset of inhalation, or during the stage of excitement and tonic spasm, *i.e.*, before true surgical anæsthesia has been produced. From this it follows that, in using chloroform for the purpose of preventing the initial discomforts of ether, we are subjecting the patient to greater risk than in employing ether alone. The risk will be in proportion to the extent to which we carry the inhalation of chloroform. If we carry it only so far as to blunt the sensibility to the pungency of ether vapour, the additional risk will be extremely small. But that an additional risk will be incurred there can be no doubt. Cases are on record (p. 223) in which a fatal result has taken place after but a few breaths of chloroform vapour. It is possible, as has been pointed out, that influences other than that of the anæsthetic itself have been at work in these cases. Still, the fact remains that similar fatalities have not been met with at the very outset of the administration either of nitrous oxide or of ether; so that we must still continue to look upon chloroform as an agent which, in very rare instances, is capable either indirectly or directly of destroying life almost immediately after its inhalation is commenced. If we carry the administration of chloroform as far as the stage in which excitement and tonic spasm are liable to arise, the risk will be again a trifle increased. It is an established fact that during muscular excitement and respiratory embarrassment under chloroform, syncope may take place.

With the above considerations before us it is questionable whether we should regard the use of chloroform before ether as a practice deserving of widespread adoption. There are, nevertheless, circumstances under which this particular succession of anæsthetics is advisable. When we meet with such cases we should commence the administration of chloroform as has already been described, upon an open inhaler, in small quantities at a time; we should give the anæsthetic gradually but continuously; and we should replace it by ether at the first signs of any mental or muscular excitement. In this manner we shall, at all events, avoid the second of the two risks above mentioned. No definite rules can be laid down as to the quantity of chloroform which should be given in any particular case. The chloroform must not on the one hand be removed too soon; nor must it on the other be withdrawn too late. Should it be given for a few seconds only, and the ether inhaler then applied, the patient, though perhaps not conscious of the change of vapour, may give trouble with swallowing, arrested breathing, coughing, &c. Should it be continued till deep anæsthesia has been produced, the risk which attends the stage of excitement under chloroform, and which might have been obviated had this stage been allowed to pass over under ether, would, of course, come into play.

For administering chloroform before ether the anæsthetist should be provided with a Skinner's mask and a drop bottle for the former, and with a Clover's, Ormsby's, or Rendle's inhaler for the latter anæsthetic. If a Clover's apparatus be used, its indicator should be turned to '1' before being applied, and the strength of the vapour increased, as occasion may require, till the ordinary signs of ether anæsthesia result.

B. THE A. C. E. MIXTURE FOLLOWED BY ETHER.

When chloroform is diluted with a considerable quantity of ether—such a quantity, for example, as is present in the A. C. E. mixture—it is extremely probable that the risks attendant upon the early stages of its administration almost cease to exist. Mixtures considerably richer in chloroform than the A. C. E. mixture would necessarily be liable to much the same objection as that which is attached to chloroform itself. The quantity of ether in the A. C. E. mixture, although considerable, is not sufficient to make the mixture unpleasant to inhale. The vapour of this mixture is, indeed, by no means disagreeable when administered slowly and with plenty of air.

This succession of anæsthetics is worthy of special notice. The advantages which it possesses are :—Firstly, that the administration of the two agents is extremely simple, and requires no complicated apparatus; secondly, that no closely-fitting mask is used for commencing the administration; thirdly, that the initial sensations of the patient are by no means unpleasant; fourthly, that there is no alteration in the colour of the features during the induction of anæsthesia; fifthly, that tonic muscular spasm and temporarily embarrassed respiration are very rarely met with, and, should they occur, quickly subside; and, lastly, that the method seems particularly adapted for anæsthetising patients who are usually regarded as bad subjects for anæsthetics.

It is somewhat difficult to offer any adequate explanation of the satisfactory effects of the A. C. E. mixture followed by ether in those patients who are usually looked upon as unsatisfactory subjects. Tall muscular men, alcoholic individuals of both sexes, bloated and stout patients with every evidence of cardiac degeneration, asthmatics, and others who would almost certainly give some trouble not only with gas-and-ether, but with ether administered by itself from a Clover's apparatus, will be found to pass into deep ether anæsthesia with remarkably little trouble if this method be carefully conducted. The A. C. E. mixture seems to supply exactly what is required for *inducing* anæsthesia in difficult cases; and ether, given from an Ormsby's inhaler, seems to be particularly well adapted for *maintaining* anæsthesia.

We must not forget that, as in all other plans of inducing anæsthesia, attention to certain points is indispensable if the administrator wishes to give his patient no discomfort, and to prevent struggling and excitement—in a word, to successfully conduct the administration. I would therefore ask the reader who is interested in the subject to pay particular attention to the following simple directions for the administration.

For successfully anæsthetising adult subjects, it is advisable to have at hand a piece of lint or a Skinner's mask (Fig. 40, p. 190), a Rendle's mask (Fig. 26, p. 136), and an Ormsby's inhaler (Fig. 35, p. 149). Clover's inhaler has in my hands proved far less satisfactory than Ormsby's for administering ether after the A. C. E. mixture to adult subjects. The mixture should be contained in a drop bottle of the kind shown in Fig. 44, p. 192. I have found it of distinct advantage, in administering the A. C. E. mixture before ether, to employ lint or a Skinner's mask for the first minute or so, and then to go on with a Rendle's mask. But should the administrator wish for greater simplicity, he may conduct the administration with but one of these, preferably Skinner's mask, before proceeding to ether. The sponges of the Rendle's and Ormsby's inhalers should be wrung out of warm water, and the two inhalers, with their mouths uppermost, placed by the side of the administrator, ready to receive the A. C. E. mixture and ether during the administration.

For anæsthetising children, a Skinner's mask, a drop bottle for the A. C. E. mixture, and a Clover's inhaler will be found convenient. The intermediate (Rendle's) inhaler is not necessary.

Method of Administration (Adults).

1. *Apply the lint or Skinner's mask loosely to the face, and allow a few drops of the A. C. E. mixture to fall upon it.* The object of first employing lint or a Skinner's mask is to prevent all choking and uncomfortable sensations which might result from a closer inhaler.

2. *Gradually increase the quantity of the mixture upon the mask till the latter becomes more or less saturated.* The patient soon becomes accustomed to the vapour, and will be found to breathe it without the slightest difficulty. Should any hesitation in breathing occur, the mask must be held a trifle further from the face.

3. *After about one minute the Rendle's mask, upon the sponge of which about half a drachm of the mixture has been poured, should be applied.* The patient will probably not notice any change in the masks, and will continue to breathe without discomfort.

4. *Add more of the mixture (about half a drachm) from time to time, removing the mask for the purpose.* Whilst the administration is thus proceeding, the administrator should pour about one ounce of ether on the sponge of the Ormsby's inhaler.

5. *After about 2–3 minutes from the commencement of the administration the Ormsby's inhaler should be very gradually applied.* I have met with two main guides as to the proper moment at which the change to ether should be effected; (1) deep and audible but non-stertorous breathing; and (2) commencing tonic contraction of the arms. As a general rule the first is an excellent guide.

6. *Apply the Ormsby's inhaler during an expiration, and do not at first press it tightly upon the face.* As a general rule the first inspiration is a trifle held, and one or two acts of deglutition occur. In a few seconds, however, the patient breathes in and out of the bag. The face-piece should now be tightly applied.

7. *Stertor and muscular relaxation will now quickly appear.* Should the A. C. E. mixture have been carried rather further than necessary, *i.e.*, to the border-land of excitement and tonic spasm, it will be found that all inconvenient symptoms will quickly subside if the Ormsby's inhaler be kept applied.

The administration should now be conducted as already described on p. 162.

The following case illustrates the effects produced by this succession of anæsthetics:—

Illustrative Case, No. 23.—M., about 35. One of the most powerful men I have ever seen. Chest measurement, 43 inches. Thick, large neck. Florid colour. A great athlete. Has lived well. Operation, radical cure of hydrocele. Duration, one hour. Administration begun at 9.50 A.M. with Skinner's mask. No holding of breath. When Rendle's mask applied there was occasional swallowing, but good respiration. Administration thus continued till breathing deeper. Changed to Ormsby charged with pure ether. More swallowing, and slight but not inconvenient movement of hand. Breath held very slightly. Some tonic spasm in neck and other parts, but no inconvenient movement. A breath of air given. Soon deeply snoring, but still a trifle rigid. At 10.20 pupils ● to ● (=2½ to 3 mm.), the right size for this particular case; they had been ● (=3½ mm.). Very deep stertor. Pulse 114: very full and bounding. Respiration 28: regular, deep, and loudly stertorous. Stertor lessened by pushing jaw forward. Less ether allowed some tendency to crowing breathing, and made pupils *larger*. When operation over, less ether made pupils smaller. Vomited half-an-ounce of fluid material immediately after operation. No subsequent nausea.

Method of Administration (Children).

In anæsthetising little children (p. 16) with the A. C. E. mixture, followed by ether, all that is needed is to give the mixture on a Skinner's mask till respiration has become deep and regular, and then to replace the mask by a Clover's inhaler, with its indicator turned to about '1.' Should the patient cry, the A. C. E. mixture should be administered till crying has nearly ceased, and the ether should then be applied. The following is an example:—

Illustrative Case, No. 24.—Patient a little boy, æt. 2 years 3 months. Florid. Breathes through mouth. Operation 10 A.M.: no food since previous evening. Semi-recumbent position. A few drops of A. C. E. mixture at a time on Skinner's mask. Some crying, but no resistance. After 1–1½ minutes Clover's inhaler previously charged with ether and turned to '1' applied. Anæsthesia in 2–3 minutes. Noisy regular breathing: colour rather dusky:[1] pupils ● (=3 mm.): no lid reflex: quite relaxed: pulse good and full. Total length of administration, including A. C. E. mixture, =5 minutes. Mouth opened by Mason's gag, and head arranged for good light to enter mouth. Tonsils removed by guillotine. Mouth sponged. No movement. Head and body now tilted forwards, and post nasal space cleared of adenoid growths. Blood and detached growths came away from mouth and nose without slightest embarrassment to respiration. No sponging necessary. No movement. Operation, which lasted about 3–4 minutes, now over. Head kept forwards for drainage. Some cough and movement. Child turned on his side, in which position he lay quietly breathing, and with good colour for 10 minutes. Then began to cry and move about.

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[1] This is of no importance in a florid child under ether, and is very liable to occur when the breathing is previously wholly oral. The fact of the colour being bluish, and not pallid, shows a good circulation; moreover, the colour is completely under control, for if more air be given the normal colour will at once return.

CHAPTER VII.

BROMIDE OF ETHYL, ETHIDENE DICHLORIDE, AMYLENE (PENTAL), AND OTHER ANÆSTHETICS.

A. BROMIDE OF ETHYL.

Administration and Effects Produced.—The anæsthetic properties of bromide of ethyl were first recognised by Nunneley of Leeds in 1849, who spoke highly of the drug. Rabuteau [1] and Turnbull [2] were the next to investigate its anæsthetic properties The latter has used it in a considerable number of cases, and has on more than one occasion brought its anæsthetic merits before the notice of American surgeons, several of whom, including Dr. Chisholm,[3] Dr. Levis, Dr. Marion Sims, and others, have used it with more or less success. Sir B. W. Richardson [4] considers the bromide a good and efficient anæsthetic. Mr. Clover, however, gave the agent a trial, but was not favourably impressed with it.[5] Dr. H. C. Wood of Philadelphia is also opposed to its introduction into general use. Drs. Schneider and Herz,[6] as well as other German dentists, have recently used bromide of ethyl in their practices, and speak highly in its favour for dental operations. Finally, Dr. J. F. Silk [7] has investigated the properties of the bromide as an anæsthetic in this branch of surgery. He has administered it in over 130 cases, and has taken notes of the effects produced. I have therefore largely availed myself of the information and conclusions contained in Dr. Silk's paper on the subject, feeling that as he has had a considerable experience in other anæsthetics he is in the best possible position to judge of the merits and demerits of the agent.

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[1] *Lancet*, vol. i. 1877, p. 143.

[2] 'Manual of Anæsthetics.'

[3] Dr. Chisholm has used bromide of ethyl in 3000 cases without a fatality. See *Maryland Med. Journ.*, December 5, 1880.

[4] *Asclepiad*, 1885, p. 264.

[5] *Brit. Med. Journ.*, vol. i. 1880, p. 586.

[6] *Internationale Klinische Rundschau*, April 14, 1889. See also *Lancet*, April 27, 1889, p. 848.

[7] *Trans. Odonto. Soc. of Great Britain*, February 1891.

All who have employed bromide of ethyl as an anæsthetic in surgical practice agree that it is more adapted for operations of very short duration than for others. It has hence been used somewhat extensively for producing anæsthesia during the extraction of teeth. It rapidly destroys consciousness; and recovery from its influence is correspondingly speedy.

The administration may be conducted by means of a towel or leather mask (Fig. 26, p. 136), but an Ormsby's inhaler (Fig. 35, p. 149) is the best for the purpose. A drachm, or a drachm and a half, should be placed upon the sponge of this inhaler, and the apparatus applied to the face of the patient. Dr. Silk recommends that little or no air should be admitted for the first few inhalations, after which the air-cap of the apparatus should be opened. With regard to the time occupied in producing anæsthesia, Dr. Silk says:—"In estimating the time taken to induce anæsthesia, it would obviously be unfair to include all methods of administration together. Taking, therefore, only the closed method, *i.e.*, when the Ormsby's inhaler was used, I find that I have recorded twenty observations, from which I estimate the average time of induction to be 66.8 seconds, or slightly less than in the case of nitrous oxide. The duration of the anæsthesia thus produced I found to be 46.2 seconds, an average arrived at from the consideration of twenty-eight cases—this is nearly half as long again as with nitrous oxide. Roughly speaking, the duration of the anæsthesia bears some relation to the time required for induction, but of course this is by no means absolute; and with the English samples of the drug the variability is very marked. It would certainly appear, too, that when the time from the commencement of the inhalation to the end of the anæsthesia exceeds two minutes, the after-effects are very likely to be troublesome."

Of 300 cases in which Dr. Chisholm administered the bromide of ethyl the time required to produce deep anæsthesia was not more than 60 seconds.

As to the signs of anæsthesia, the administration should be conducted till softly snoring breathing, or insensibility of the cornea, is produced. Should there be delay in the supervention of these signs, the inhaler should be removed on the detection of any feebleness or irregularity in the pulse. A single and continuous administration of the agent in this manner is not likely to be attended by any unpleasant after-effects; but a re-application of the inhaler will be liable to induce nausea and vomiting. An intermittent administration, such as that which would be necessary for a prolonged operation, is therefore not to be recommended. Dr. Marion Sims[1] performed Batty's operation, using bromide of ethyl as the anæsthetic, and the administration lasted 1½ hours. Vomiting occurred several times; the conjunctiva was sensitive from the beginning to the end; opisthotonus, very rapid breathing, and violent straining were produced. Severe pain in the head followed the inhalation, and after attacks of diarrhœa, tenesmus, and convulsions, the patient died (21 hours after the operation). Dr. Levis of Philadelphia has administered the bromide for 40 consecutive minutes with an expenditure of 11 drachms. Other observers also record prolonged administrations.[2]

When bromide of ethyl is administered as above recommended, respiration is not markedly affected. It remains for the most part regular, and free from those temporary embarrassments which are common with nitrous oxide or ether.

Professor Wood of Philadelphia regards bromide of ethyl as a cardiac depressant. During its administration the pulse usually becomes increased in rate, and somewhat diminished in force. In several of the patients to whom Dr. Silk administered the bromide he found that distinct irregularity and slowing of the pulse were to be detected.

Struggling and excitement are exceptional. Dr. Turnbull records hysterical excitement in six out of 100 cases. This absence of early excitement is doubtless a great point in favour of the bromide. The pupils usually dilate during the administration, and some increase of saliva occurs.

Dangers connected with the Administration.—Several deaths have occurred during or immediately after the administration of this anæsthetic; but as it is difficult or impossible to ascertain the number of times bromide of ethyl has been employed, the actual death-rate is unknown. There is good reason to believe that the risks attendant upon the administration have been overestimated, and that if a pure drug be employed, and ordinary care exercised, the rapid induction of anæsthesia sufficient for the performance of a short operation is attended by little or no danger. Dr. Silk, who has investigated all the published fatal cases, says "that the fatalities recorded appear to have resulted (1) at the commencement of the inhalation from sudden heart-failure; (2) at a somewhat later period presumably from respiratory paralysis; or (3) some hours after the administration from severe gastro-intestinal irritation, such as might result from irritant poisoning."

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[1] See a paper read before the New York Academy of Medicine, March 1880, entitled 'The Bromide of Ethyl as an Anæsthetic.' By J. Marion Sims, M.D.

[2] See Norton, *Brit. Med. Journ.*, May 15, 1880, p. 735.

After-Effects.—As with other agents the after-effects bear a kind of proportion to the duration of the anæsthesia. A short administration is usually not followed by headache or nausea, the patient regaining consciousness very satisfactorily. It is not very uncommon, however, for some degree of depression to be experienced, and in some cases actual fainting has been recorded. Hysterical outbursts may sometimes follow the inhalation. Nausea and vomiting are exceptional after a single administration; but during or after a comparatively long inhalation they will be liable to result.

Looked at from all points of view bromide of ethyl can hardly, I think, be regarded with much favour. As compared to nitrous oxide gas it is distinctly inferior not only in point of safety, but in the greater liability after its administration to headache, nausea, and other unpleasant effects. Before any very definite opinion, however, can be expressed as to its suitability for use in dental and other minor surgical operations, a more extensive trial of the drug should be made. Its greater portability is necessarily a recommendation when we compare it with nitrous oxide; but its liability to decomposition quite outweighs this advantage.

B. ETHIDENE DICHLORIDE.

Administration and Effects Produced.—Ethidene dichloride was first employed as an anæsthetic by Snow,[1] who administered it on several occasions with good results. Snow found the effects to be nearly the same as those of chloroform. In 1870 it was used by Leibreich and Langenbeck in Berlin,[2] and by Sauer,[3] and Steffen.[4] In 1879 the Glasgow Committee of the British Medical Association[5] drew attention to the merits of the anæsthetic, and, after a careful comparison of its action with that of chloroform, published their results in the following year. Fifty operations were performed under ethidene dichloride, fifty under chloroform, and the results tabulated. They found the average dose of ethidene to be 40.3 c.c., or 1.8 c.c. for each minute during which the patient was under its influence. With chloroform the average dose was 31.8 c.c., or 1.7 c.c. per minute. The time taken to produce anæsthesia was, in the case of ethidene dichloride, 4.3 min.; whilst with chloroform it was 5.4 min. Less excitement was observed than with chloroform. The committee found that both the pulse and the respiration under ethidene dichloride were less altered than when chloroform was used. They did not obtain the marked slowing of the pulse and the quick respiration which are often observed with chloroform. Ethidene dichloride was regarded by the committee as midway, in point of safety and in other respects, between chloroform and ether; and after their eulogistic account of its action it was for a time largely used. Mr. Tom Bird [1] has recorded six administrations by means of Junker's apparatus. Mr. J. H. Palmer [2] has also reported his experiences with the agent administered upon lint or by means of a towel. He found that one ounce was required to anæsthetise a boy of 18 for an operation lasting 35 minutes. We are indebted, however, to Clover [3] for the records of no less than 1877 administrations of ethidene dichloride, and his results are of great interest. Of the 1877 administrations 287 were for major operations. Clover usually preceded the administration of ethidene by nitrous oxide gas, using his gas-and-ether inhaler (Fig. 36, p. 176) for the purpose. The vapour of ethidene was gradually added when the patient was partly anæsthetised by nitrous oxide. By this method struggling was rarely met with. A little convulsive twitching occurred as anæsthesia approached, and this was quickly followed by stertor and dilatation of the pupils. Air was then admitted as occasion required; and the quantity of ethidene given was regulated by the general condition of the patient. Clover seems, in fact, to have administered ethidene in very much the same way as he employed ether *i.e.*, with a limited supply of air.

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[1] Most of the information contained in the present chapter is derived either from the reports of the Glasgow Committee on Anæsthetics (*Brit. Med. Journ.*, Dec. 18, 1880, p. 958); from a lecture given by the late Mr. Clover (*Brit. Med. Journ.*, May 29, 1880, p. 797); or from Dr. Snow's article on 'Monochlorurretted Chloride of Ethyle' (*op. cit.*, p. 420).

[2] *Berlin Klin. Wochenschrift*, Nos. 31 and 33, 1870, p. 401.

[3] *Pharm. Centralblatt*, vol. xiv. p. 140.

[4] *Deutsche Klinik*, No. 44, p. 398, and *Jahresb. der Medicin*, 1870-1-2.

[5] *Brit. Med. Journ.*, vol. i. 1879, p. 108.

Dangers connected with the Administration.—Sauer, to whom reference has already been made, has recorded a fatality under ethidene in a patient who was the subject of morbus cordis. Another fatality is reported by Clover; [4] but from the published account of the case the anæsthetic seems to have but little share in bringing about the fatal syncope which followed the administration. The patient had a large flabby heart, and syncope took place whilst the head was being voluntarily raised after the operation was over. A third case is put on record by Dr. Mouillot.[1] The patient was the subject of empyema, and died with symptoms of syncope soon after the stage of struggling. A fourth fatality is mentioned[2] as having occurred during an ophthalmic operation. Pallor and disappearance of the pulse were noticed at the moment the cornea was incised. It may be incidently mentioned that ethidene seemed at one time to be specially suited for ophthalmic operations, owing to the infrequency of struggling during its administration, and of vomiting afterwards. There can be no doubt, however, that ethidene, although more stimulating than chloroform, is yet to be regarded in this respect as inferior to ether. Clover refers to three cases in which alarming symptoms presented themselves during the administration, and in his remarks on the fatality above alluded to, states his belief that ether would have been safer than ethidene.

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[1] *Med. Times and Gaz.*, vol. i. 1879, p. 62.

[2] *Lancet*, vol. ii. 1879, p. 637. Mr. Palmer obtained his ethidene from Kalbaum of Berlin, through some London chemists.

[3] *Brit. Med. Journ.*, May 29, 1880, p. 797.

[4] *Loc. cit.*

After-Effects.—According to Clover, patients recover from ethidene anæsthesia very satisfactorily. He found vomiting to occur in one-third of his administrations for major operations, and in one-twentieth of those for minor operations. He further states that vomiting after ethidene invariably ceases sooner than after chloroform. Of thirty-three cases mentioned by Sauer, two vomited, and two had nausea and headache after. The Glasgow committee found that nausea and vomiting were about equal in frequency after ethidene and after chloroform, but that vomiting after ethidene was of shorter duration than that after chloroform.

C. AMYLENE. PENTAL.

Amylene.

Administration and Effects Produced.—For most of our present knowledge concerning the effects produced by amylene we are indebted to Snow, who, as already mentioned, was the first to employ this substance as an anæsthetic. Snow used it in 238 cases, and found that the best results were obtained by administering it with his chloroform inhaler (p. 187). The great volatility of amylene almost necessitates the use of some special apparatus. Snow found that three to four fluid drachms were required to cause insensibility in the adult, and that about 15 per cent. of the vapour should be breathed with air. Amylene appears to differ from chloroform in that the continuous administration of a very dilute vapour does not lead to anæsthesia; it is necessary to exhibit the agent in a somewhat concentrated form. Owing to the sparing solubility of amylene in the blood, and to its great volatility, patients very rapidly emerge from its influence, so that a frequent renewal of the inhalation is necessary. Snow estimated that amylene was consumed at about the rate of one fluid drachm per minute, when administered by means of his apparatus.[1]

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[1] *Brit. Med. Journ.*, vol. i. 1881, p. 385.

[2] *Brit. Med. Journ.*, vol. ii. 1882, p. 1267.

In most of Snow's administrations an analgesic and not a truly anæsthetic state appears to have been obtained. He declared, indeed, that he found it possible to secure an absence of pain with a less profound coma than that which characterised the use of chloroform or ether. The lid-reflex was not as a rule abolished, although muscular movements in reflex response to operative interference were usually absent. Both major and minor operations were performed during this comparatively light form of anæsthesia. The pulse was almost always increased in frequency and force. The respiration was often accelerated. The pupils were most commonly about the ordinary size. The colour of the features was heightened. Perspiration was met with in some cases. It was found that amylene could not be depended upon for producing complete muscular relaxation, and that it was not a very convenient anæsthetic for prolonged operations about the mouth or face. It appeared to answer best in short operations not requiring muscular flaccidity, such as those for the extraction of teeth. Less salivation was observed than under ether or chloroform.

Soon after the introduction of amylene by Snow it was tried somewhat extensively both in this country and abroad. The conclusions arrived at by a Committee of the Academy of Medicine were:[2] That rigidity was the rule rather than the exception during amylene administration; that a remarkably rapid recovery from its effects occurred; and that it was more suitable for brief operations than for others. Its unpleasant odour was regarded as a barrier to its general employment. M. Giraldès administered amylene to 79 children, and stated that two drachms were required in most cases to produce insensibility to pain. According to Kappeler,[3] amylene was given a fair trial by Spiegelberg and Lohmayer, who were unable to obtain complete anæsthesia with it; whilst Billroth and Jüngken found it answered well as an anæsthetic, even in major operations (resection of os calcis, amputation of leg, &c.).

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[1] *Med. Times and Gaz.*, Jan. 17, 1857, p. 60.

[2] See *Med. Times and Gaz.*, vol. i. 1857, p. 623.

[3] *Op. cit.*, p. 192.

Dangers connected with the Administration.—Of Snow's 238 cases there were two fatalities; but in discussing these by the light of our present knowledge it is questionable whether they should be directly attributed to the influence of the anæsthetic. In one case the pulse failed at the moment the incision was made for *fistula in ano*, the patient being only lightly under the anæsthetic. In the other the patient was in the prone position,[1] and, from the fact that breathing had been observed to be noisy and snoring, it is quite possible that other factors than the toxic action of the amylene may have been at work. These, however, are merely conjectures. The patients appear to have died from cardiac failure in much the same way that has frequently been observed in the case of chloroform. The occurrence of these two fatal cases had the effect of lessening the confidence of the profession in the new anæsthetic; and it does not appear to have been again employed, at all events as amylene. The body now being introduced as pental will be discussed below.

After-Effects.—Patients recover with remarkable rapidity from the effects of amylene. Nausea and vomiting are quite exceptional. Of Snow's 238 cases there were only two in which vomiting occurred immediately after the administration; and sickness was only heard of subsequently in eight or ten cases.

Pental.

The substance known by this name has been already referred to (p. 14). What the precise differences between it and its predecessor amylene may be, further experience must decide. Pental has been somewhat extensively used in Germany as an anæsthetic in dental surgery, and the following remarks, for most of which I am indebted to Mr. T. E. Constant[2] of Scarborough, apply to its employment in this branch of practice.

Administration and Effects Produced.—A Clover's ether inhaler (p. 139), or some similar apparatus, answers best. Two drachms, or a little more, should be poured into the reservoir. The bag being attached, the patient's expirations may be allowed to partly fill the bag. The indicator must be turned to '1' when the apparatus is applied to the face. No more air should be given, but the patient should breathe to and fro for about

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[1] See p. 32.

[2] The pental used by Mr. Constant was procured from C. A. F. Kahlbaum of Berlin.

40 seconds, the indicator being progressively pushed towards 'F.' The symptoms produced are similar to those recorded by Snow. The eyes often remain open. It is sometimes possible to obtain true analgesia, the patient retaining consciousness whilst a tooth is painlessly extracted. At the end of about 40 seconds, the inhaler is removed and the extraction commenced. Anæsthesia is stated to persist for about a minute after the removal of the face-piece.

Dangers connected with the Administration.—A fatality in connection with the use of pental has been recorded,[1] but it is difficult to say, with the facts before us, what share the anæsthetic had in the causation of the symptoms. A case has also been reported to me in which the most alarming symptoms occurred immediately after the inhalation. Respiration grew shallow and then ceased, whilst the radial pulse became imperceptible. Inversion restored the pulse; but artificial respiration for seven minutes had to be resorted to before recovery ensued. Looked at from all points of view the use of amylene or pental seems to have but little to recommend it. As compared to nitrous oxide gas for brief operations it is certainly inferior, not only because of its greater danger, but because it is not so agreeable to inhale.

After-Effects.—As with the amylene employed by Snow, after-effects are usually completely absent.

D. OTHER ANÆSTHETICS.

There are numerous other agents which have been used for the production of general anæsthesia; but they are all inferior, in one way or another, to those already discussed.

Nitrogen is capable of producing insensibility to pain when inhaled free from oxygen, or with very small percentages of that gas. The anæsthesia must be regarded as the result of oxygen-deprivation, for it is obvious that we cannot assign any specific anæsthetic properties to nitrogen itself. In 1868,[2] Professor Burdon Sanderson, the late Dr. John Murray, and Mr. J. Smith Turner administered nitrogen for tooth-extraction to six patients at the Middlesex Hospital. In the first two cases a considerable quantity of air appears to have been breathed with the nitrogen; and even in the remaining four cases there is good reason to believe, from the results obtained, that in some way or another small quantities of oxygen must have gained access to the lungs during the administration. Thus, insensibility did not occur till from three to four minutes after the commencement of the inhalation; no lividity of the features was observed; and in only two of the four cases was there an absence of pain during the operation.

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[1] See *Brit. Journ. Dent. Science*, June 1 and 15, 1892.

[2] See *Brit. Med. Journ.*, June 13, 1868, p. 593.

On May 13, 1890, I administered, at the Dental Hospital, for Sir George Johnson, nitrogen with .5 per cent. of oxygen (*i.e.*, practically pure nitrogen) to nine patients. There was no excitement in any case. An onlooker could not have detected any difference between the phenomena produced and those usually met with under nitrous oxide. I used the same apparatus which I employ for nitrous oxide (Fig. 18, p. 95), and took great care that the face-piece fitted well and that the valves worked accurately, so that no air whatever might gain admission to the lungs. Anæsthesia was produced with remarkable rapidity in each case. The available period of anæsthesia for a dental operation was, with one or two exceptions, shorter than with nitrous oxide. There was reflex screaming in some of the cases; but this is also met with under nitrous oxide, more especially in hospital practice. I administered the nitrogen in each case till slight epileptiform movements appeared. The recovery was quick and good. There was no nausea or vomiting. The pulse was usually rapid, and I am inclined to think not so strong as under nitrous oxide.

On May 26, 1890, I administered nitrogen with 5 per cent. of oxygen to five cases; and nitrogen with 3 per cent. of oxygen to four cases. A longer time was taken to produce anæsthesia than with the practically pure nitrogen; but the period of inhalation was still remarkably short. The resulting anæsthesia seemed to be longer than that obtained by nitrogen alone. No excitement was noted in any case. During the administration there was less jactitation in these than in the preceding nine cases. In one case three teeth were painlessly extracted. There was some excitement after the inhalation in a few of the cases. One patient, a boy, complained of much headache, and cried with pain. In one case there was rapid tremor of one arm after the administration. This phenomenon I also observed in one of the pure nitrogen cases. All patients exhibited jerky and irregular breathing, with cyanosis.

On May 29, 1890, I administered nitrogen with 5 per cent. of oxygen to one case. The anæsthesia was not satisfactory. On the same day I administered to two cases nitrogen with about 6.6 per cent. of oxygen. There was a longer period of inhalation than with the 5 per cent. of oxygen, and some apparent discomfort and uneasiness. In one of these cases I pushed the administration till slight clonic movements, irregular respiration, and cyanosis occurred. The anæsthesia was then complete for a short operation.

On June 3, 1890, I administered nitrogen with 7 or 7½ per cent. of oxygen to two patients. In both thero was distinct anæsthesia. In one case, a woman, there was no jactitation, but some cyanosis, and the patient was quiet throughout. In the second, a woman, the symptoms were like those of pure nitrogen or nitrous oxide, coming on more quickly. There was definite anæsthesia.

Sir George Johnson, in his report of the above administrations of nitrogen with .5 per cent. of oxygen, states that "the maximum period required to produce anæsthesia was 70 secs., the minimum 50 secs., and the mean time 58.3 secs." With regard to the cases in which 3 per cent. of oxygen was present, Sir George Johnson states that "the time required to produce anæsthesia varied from 60 to 75 secs., the average time being 67.5 secs." Referring to the cases in which 5 per cent. was present, he states that "the time required for the production of anæsthesia ranged from 75 to 95 secs., the average being 87.5 secs."[1]

Although anæsthesia undoubtedly follows the inhalation of nitrogen, the results are not so satisfactory as when employing nitrous oxide. As in the case of the latter gas, a continuous inhalation is necessarily impossible, so that only very brief operations can be performed under its influence.

Ethyl chloride, C_2H_5Cl, a colourless mobile liquid with a pleasant odour, and boiling at 12°.5 C. (Regnault),[2] is described by Richardson[3] as a good anæsthetic. It is extremely soluble in alcohol. When thus dissolved, the solution may be kept in well-stoppered bottles, and the ethyl chloride obtained by gently heating. According to Kappeler,[4] the anæsthetic properties of ethyl chloride were recognised by Flourens and others, and it was used successfully in several cases by Heyfelder.

Methyl oxide, or **di-methyl ether,** $(CH_3)_2O$, a gas of an agreeable odour, and capable of being condensed to a mobile liquid boiling at − 21° C. (Berthelot), has been used as an anæsthetic by Richardson,[5] who speaks in its favour. In twenty-seven instances sufficient insensibility was induced to permit of the painless extraction of teeth; and in all cases recovery took place within a minute. Analgesia rather than true anæsthesia appears, however, to have been produced.

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[1] For further information see *Lancet*, April 11, 1891, p. 815. Sir George Johnson gives the details of some administrations of nitrogen conducted for him by Mr. Woodhouse Braine.

[2] Roscoe and Schorlemmer, vol. iii. part i. p. 344.

[3] *Med. Times and Gaz.*, Dec. 28, 1867, p. 693.

[4] *Op. cit.*, p. 185.

[5] *Asclepiad*, 1887, p. 135; *Med. Times and Gaz.*, vol. i. 1868, p. 581.

Ethylene, or **olefiant gas,** C_2H_4, was administered by Nunneley of Leeds in 1849 to four patients; but it was found to be unsatisfactory in its action.

Amyl hydride,[1] **amyl chloride,**[2] **ethyl nitrate,**[3] **benzene,**[4] and **turpentine**[5] have one and all been found to be capable of producing general anæsthesia when administered in the form of vapour.

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[1] *Lancet*, vol. i. 1885, p. 101; *Asclepiad*, 1885, p. 168; *Med. Times and Gaz.*, Dec. 28, 1867, p. 694.

[2] Kappeler, *op. cit.*, p. 190.

[3] Snow, *Med. Times and Gaz.*, Jan. 17, 1857, p. 61.

[4] Snow and Richardson, *Med. Times and Gaz.*, Jan. 17, 1857, p. 61, and Dec. 28, 1867, p. 694.

[5] *Med. Times and Gaz.*, Dec. 28, 1867, p. 694; and Kappeler, p. 193.

CHAPTER VIII.

THE USE OF MORPHINE IN CONJUNCTION WITH GENERAL ANÆSTHETICS.

In 1861 a case was reported by Pitha in which he succeeded in deeply anæsthetising a patient by the combined action of belladonna and chloroform, after chloroform itself had proved ineffectual. In 1863 Nussbaum[1] of Munich employed morphine in conjunction with chloroform, by injecting it *during* chloroform anæsthesia. He used from .03 to .06 grm. of the acetate of morphine, and found that patients thus treated remained in a deep sleep for a considerable time after the withdrawal of the chloroform, and then woke without nausea or vomiting. At about the same time Claude Bernard observed similar effects in dogs; and in 1869[2] published his researches.

MM. Labbé and Guyon[3] seem to have been the first to administer morphine *before* chloroform in surgical practice. They adopted this plan, not with Nussbaum's original object, viz., that of lessening the after pain of operations; but with Claude Bernard's idea, viz., that of facilitating the action of chloroform, and rendering far smaller quantities of the anæsthetic than usual necessary. They injected morphine about 20 minutes before chloroform was given, and found that by this practice the excitement stage of chloroformisation was very considerably lessened, and that when once anæsthesia had been produced, extremely small doses of the anæsthetic were needed to maintain insensibility to pain. In the same year Demarquay[4] drew attention to the special dangers which might arise from the combined action of the two drugs, and considered morphine contra-indicated, more especially in weak subjects. In 1877 Thiersch[5] employed the method in several operations about the mouth, and found it possible to maintain an analgesic state in which the patient, although unable to feel pain, could aid the operator by coughing out blood, &c., when requested to do so. Within more recent times other surgeons have advocated this preliminary injection of morphine. Thus, Dr. Alexander Crombie of the Bengal Army, writing in 1880,[1] stated that he had then employed it in 600 cases with excellent results. He advocates the injection of one-sixth of a grain immediately after the beginning of the administration of chloroform, and finds that there is less vomiting than with chloroform alone, and that there is a striking absence of all asphyxial symptoms during the chloroformisation. Kappeler has devoted much attention to the subject, and by comparing the effects of chloroform without morphine and chloroform with morphine, in the same patient, on different occasions, concludes that the mixed anæsthesia is quieter, that the excitement stage is much shortened, that the patient is brought with less muscular action into the stage of 'tolerance,' that irregularities in breathing, leading to asphyxial symptoms, are conspicuously absent, and that much less chloroform is required. He finds, however, that vomiting is more frequent than with chloroform alone. Kappeler prefers to inject morphine 20 to 30 minutes before the chloroform is given, and uses in adults .015 grm., and in children .01 grm.

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[1] The *Bavarian Med. Intelligencer* for Oct. 1863 is stated to contain Nussbaum's paper. See also Kappeler, *op. cit.; Med. Times and Gaz.*, vol. i. 1864, pp. 259 and 596; *Med. Times and Gaz.*, vol. i. 1872, p. 350.

[2] *Lancet*, vol. ii. 1869, p. 789.

[3] *Med. Times and Gaz.*, March 23, 1872, p. 359.

[4] *Med. Times and Gaz.*, Sept. 21, 1872, p. 334.

[5] *Lancet*, Dec. 8, 1877, p. 861.

Professor Victor Horsley [2] has pointed out that the combination of morphine and chloroform is especially valuable in cerebral surgery, owing to the diminished vascularity of the brain and its meninges which morphine produces. He employs a subcutaneous injection of morphine a short time before the chloroform is given.

One of the latest writers on the subject is Dr. Julliard of Geneva,[3] who advises the injection of one-sixth of a grain of morphine 20 minutes before ether is given. He very properly insists, however, that a preliminary trial of morphine some days before the operation should be made, in order to ascertain the patient's susceptibility to the drug. Dr. Julliard finds that patients are more quietly etherised after morphine than under ordinary circumstances. He also uses far less ether to keep up anæsthesia, and indeed in many cases is able to secure an analgesic effect. Curiously enough, Kappeler states that he met with many failures in giving ether after morphine, and with more excitement than usual.

Morphine, when employed hypodermically before chloroform, is often combined with atropine, the latter being given in doses of about $\frac{1}{100}$th or $\frac{1}{120}$th of a grain. According to Schafer[1] and others, atropine acts as a preventive against cardiac inhibition. Moreover, the secretion of saliva is said to be lessened by using atropine in this manner. Many eminent French surgeons employ morphine and atropine before chloroform and ether, and their results are reported to be very satisfactory.[2]

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[1] *Practitioner*, Dec. 1880, p. 401.

[2] *Brit. Med. Journ.*, vol. ii. 1886, p. 670.

[3] *Op. cit.* See also *Brit. Med. Journ.*, vol. i. 1891, p. 920.

Whilst there can be no doubt that the use of morphine in conjunction with general anæsthetics is of distinct advantage in many cases, we must not lose sight of the fact that weighty objections to the routine employment of this mixed narcosis undoubtedly exist. In addition to Demarquay, others have raised a warning voice as to the danger of employing opiates in conjunction with anæsthetics in certain cases. Dr. E. H. Jacob[3] of Leeds points out that there may be some risk in administering ether to patients already under the influence of an opiate, and cautions surgeons to be on the alert for this contingency when operating for hernia, as patients with that affection are often under opium at the time the anæsthetic is given. Mr. Clement Lucas[4] states that he has seen two cases of collapse and death after operations for hernia, and believes that the morphine was to a great extent answerable. These views are quite in accordance with those which I ventured to express in 1886. When writing in that year I was unaware that any attention had previously been directed to the dangers of the mixed narcosis. I then published[5] details of a case in which, during the operation for the removal of a cerebral tumour, the patient being at the time under the combined influence of morphine and chloroform, respiratory paralysis took place. The case possessed so many points of interest that I may perhaps be allowed to again refer to it.

Illustrative Case, No. 25.—M. K., a female patient, æt. 26, was admitted into hospital suffering from symptoms undoubtedly due to the presence of a cerebral tumour. The day before the operation she could not be roused; her pupils were large, active to light, and equal; her pulse was 84; her respiration 18, and shallow; and she had right hemiplegia involving the face. On the day of operation she was quite unconscious; her respiration was 24, and somewhat noisy; and her pulse 100. One-third of a grain of morphine was injected subcutaneously, and the administration of chloroform (diluted with one-fifth of ethylic alcohol) was commenced by means of Junker's inhaler. Slight coughing and feeble struggling were noted. Corneæ insensitive in about four minutes. Once only after this was it necessary to re-apply the chloroform for a few seconds. One drachm of the anæsthetic was required altogether. When operation commenced pulse regular but weak, and respiration shallow. Forty minutes after the administration was begun breathing gradually ceased. Artificial respiration twice restored breathing for a short time. One hour after administration commenced breathing ceased for third time, and could not be re-established. *Artificial respiration by Silvester's method was kept up continuously for four hours.* If artificial respiration was suspended, cyanosis ensued, and the pulse became feebler. About 2¼ hours after administration commenced it was decided to attempt to complete the operation. This was successfully accomplished, artificial respiration being carried on the whole time. At the end of four hours automatic breathing returned, and the patient was moved off to bed.

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[1] *Brit. Med. Journ.*, Oct. 16, 1880, p. 620. Also *Brit. Med. Journ.* vol. ii., 1880, p. 240.

[2] See an interesting letter by Dr. Cockburn Smith, *Lancet*, Oct. 10, 1891, p. 843.

[3] *Brit. Med. Journ.*, vol. i. 1881, p. 30.

[4] *Brit. Med. Journ.*, vol. i. 1882, p. 500.

[5] *Practitioner*, 1887, vol. xxxix. p. 93.

It is difficult to say what was the actual cause of the cessation of breathing in this case. Whilst the anæsthetic may have been the exciting cause, it is obvious from the fact that artificial respiration had to be kept up for four hours before automatic breathing would return, that other more potent influences were at work, and amongst these the morphine probably held a prominent position.

Since the case above related, I have seen others in which the use of an opiate before the administration of an anæsthetic has led to peculiar symptoms during anæsthesia. It is often possible, indeed, to tell from the manner in which the patient behaves under chloroform or ether that he has been taking morphine in some form or another. He passes with remarkably small quantities of the anæsthetic, and without any muscular spasm, into deep anæsthesia : his breathing is often abnormally slow : and unless very small quantities of the anæsthetic be used, respiration may become unexpectedly impaired. Surgeons do not always acquaint the administrator with the previous treatment their patients have received, and the anæsthetist should therefore be on his guard. In feeble and exhausted patients, in those who are lethargic or semi-comatose, and in those with any respiratory difficulty, I am fully convinced that the advantages obtainable from morphine are not sufficiently weighty to counterbalance the risks attendant upon its employment.

In the two following cases, which appear to me worthy of brief notice, the state of the patient *after* the operation seemed to be due to the effects of morphine given whilst the patient was still under the influence of the anæsthetic.

Illustrative Case, No. 26.—F., about 38. Perityphlitis and intestinal obstruction of four days' standing. Abdomen much distended.

Frequent vomiting. Rapid respiration, entirely thoracic. A. C. E. mixture given. Abdominal section. Operation lasted about an hour. Good colour at end of operation, and fair pulse. No tracheal râles. Twenty minutes later 40 minims of Tr. opii given by rectum. In 45 minutes patient cyanosed, and in great respiratory distress. Cheyne-Stokes breathing.[1] Patient propped up in bed. Breathing gradually became calmer, and in about two hours the duskiness had passed off.

Illustrative Case, No. 27.—M., æt. 19. Fair state of health. Perityphlitis. Removal of vermiform appendix. A. C. E. mixture given throughout, except for 15 minutes in middle of administration, when chloroform was used by the request of the surgeon. Duration of administration one hour and a half. Satisfactory anæsthesia. Respiration always quick. Pulse good. At end of operation $\frac{1}{2}$ grain of morphine introduced into rectum: patient still well under anæsthetic. Swallowing movements came on, but no cough or attempt at vomiting. Respiration became extremely quiet. Could not rouse patient. Pupils moderately contracted. Colour began to grow dusky, but duskiness kept in check by flicking chest with towel and so stimulating respiration. Pulse rather feeble. He lay like this for 45 minutes, with no cough, although some mucus could be heard at back of throat. Some moaning and restlessness. Symptoms gradually subsided, and case did very well.

In the two last-mentioned cases I have every reason to believe that the opiate was the cause of the peculiar symptoms observed; for I have not met with such symptoms after anæsthetics when no morphine has been given.

Several fatalities have been recorded in which the fatal symptoms were partly if not wholly due to the combined influence of the opiate and the anæsthetic.[2]

Should it be decided to administer morphine before chloroform or ether, the susceptibility of the patient to the drug should be previously ascertained. One-sixth of a grain, with or without $\frac{1}{120}$th of a grain of atropine, is often sufficient; but one quarter or one-third of a grain are more commonly employed. Larger doses may be needed in exceptional cases. The injection is best made about 20 minutes beforehand. The anæsthetic should be gradually given till the usual signs of deep anæsthesia appear. It should then be discontinued, and not re-applied till the patient shows very distinct signs of coming round. As little as possible of the ether or chloroform should be subsequently administered: the conjunctival reflex should be retained: and an analgesic rather than a truly anæsthetic state aimed at. The objections which usually attend upon imperfectly established anæsthesia do not apply with anything like their usual force when morphine has been given.

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[1] See 'The Influence of Certain Drugs on Cheyne-Stokes Respiration.' By G. A. Gibson, M.D. *Practitioner*, vol. xxxviii. 1887, p. 85.

[2] See *Med. Times and Gaz.*, vol. i. 1867, p. 633; *Brit. Med. Journ.*, vol. i. 1881, p. 69 (several cases quoted), and vol. i. 1882, p. 501.

In administering an opiate, either subcutaneously or by the rectum, after the withdrawal of the anæsthetic, it is advisable to wait till the patient displays distinct signs of recovery from the anæsthetic. Should much mucus be present within the air-passages, morphine should be withheld till the mucus has either been coughed out or swallowed. It is needless to add that when any pre-existing respiratory affection is present, opiates should not be given.

PART III.

THE MANAGEMENT AND TREATMENT OF THE DIFFICULTIES, ACCIDENTS, AND DANGERS OF GENERAL ANÆSTHESIA.

PRELIMINARY NOTE.

It may seem to many that unnecessary stress has been laid upon this part of the subject. The reader must not imagine, however, that the numerous difficulties, accidents, and dangers about to be discussed are of such common occurrence as their detailed description might suggest. But seeing that troublesome and even threatening symptoms sometimes supervene in an unexpected manner, it behoves every one who gives an anæsthetic, even for the most trifling operation, to be fully conversant with the proper treatment that should be adopted. It has hence been thought desirable to go as thoroughly into the matter as possible.

CHAPTER I.

MINOR DIFFICULTIES.

In the preceding Parts of this work frequent reference has been made to the various difficulties, accidents, and dangerous conditions with which the administrator of an anæsthetic may possibly have to cope in the discharge of his duties. It has been pointed out that certain subjects are more prone to give trouble than others (Pt. I. Chap. II.); that when some operations are in progress there is a greater tendency to the supervention of threatening symptoms than when others are being performed (Pt. II. Chap. III.); and that, with each anæsthetic which has been discussed, special and peculiar phenomena of an inconvenient or possibly dangerous character may occasionally make their appearance. It will also be remembered that, when considering the preparation of the patient for the administration, reference was made to the few necessary appliances which should always be at hand for the treatment and removal of the various difficulties, accidents, and dangers which may complicate the administration (Pt. I. Chap. V.). But under whatever circumstances difficulties may arise during surgical anæsthesia their treatment should be the same. It therefore appears to me to be most convenient to consider this branch of the subject from a general standpoint.

Whilst it would perhaps be misleading to emphasise the frequency with which troublesome cases present themselves in actual practice, it would be equally misleading were we to regard these minor difficulties as unimportant. By the careful observation of the patient's symptoms; by watching with an attentive eye for the slightest deviation from what may be called the normal course; and by correcting or relieving symptoms which are in themselves but trifling, it is often possible to avoid difficulties and dangers of a serious or abiding character.

A. CONSCIOUS HESITATION IN BREATHING.

Patients sometimes give trouble by breathing in a hesitating and imperfect manner. Others hold the breath and refuse to breathe at all. With nitrous oxide such difficulties may come about from tight-lacing, from the patient being ignorant of the manner in which he should inhale, or from sheer nervousness and apprehension. The remedy in each case is sufficiently obvious. Although it is extremely rare to meet with patients who cannot breathe nitrous oxide, such patients do exist. The initial sensations may, in the case of highly nervous and excitable patients, be so unpleasant that the administration becomes impossible. Usually, any mild attempt to remove the face-piece may be successfully met by gentle remonstrance; but the anæsthetist must be guided by the time the patient has been inhaling as to whether he should continue the administration or not. With children, any crying or attempted rebellion should certainly be met by continuing the administration, for in a few seconds anæsthesia must ensue. With other anæsthetics the restricted breathing is often due to too strong a vapour; but even though a very dilute vapour be used some patients will absolutely refuse to breathe freely. In such cases encouragement and re-assurance should be brought to bear; and, above all things, the administrator should never lose patience in dealing with the difficulties he has to encounter.

B. EXCITEMENT: MUSCULAR MOVEMENT: INCONVENIENT RIGIDITY.

The stage of excitement may be so marked or prolonged that difficulty may be experienced. This is not likely to be the case with nitrous oxide when given by means of an accurately working and well fitting apparatus; nor with ether when properly administered by the close method. But the faulty administration of nitrous oxide, the use of ether by the open method, and, in certain subjects, the inhalation of chloroform in the usual manner, are one and all liable to be attended by shouting, gesticulation, violent muscular excitement, pugilistic movements, &c. When anæsthetising hysterical young women, hyper-sensitive persons of both sexes, alcoholic individuals, and those who have become addicted to morphine, chloral, &c. (p. 18), the administrator must be on his guard, and he should have assistance within easy call in case the patient should become unmanageable.

The so-called 'struggling' of patients under anæsthetics deserves a few remarks; for it is not an uncommon thing for all movements, even including those which sometimes attend the deepest form of anæsthesia, to be included under this term. It would appear that the following muscular movements may occur in connection with the use of anæsthetics:—

1. Conscious co-ordinate movements at the very commencement of inhalation.
2. Excited movements (often apparently conscious in nature) of the neck, arms, legs, and other parts, before true anæsthesia has become established.
3. Reflex movements of fingers, arms, legs, abdominal walls, and respiratory muscles during comparatively deep anæsthesia, such movements occurring as the immediate result of some sensory impression.
4. Irregular muscular twitchings in various parts of the body, such as those commonly met with under nitrous oxide gas administered free from all oxygen.
5. Fine rhythmical tremor.

The movements which are purely voluntary in nature need not further detain us. The excited muscular phenomena of incipient anæsthesia are, however, of considerable importance, for they may require delicate treatment. The circumstances under which they are most liable to occur have already been fully discussed. They seem to be often initiated by unnecessary restraint. Patients should therefore never be held or touched by assistants unless restraint really becomes necessary. Should the patient's movements be such that he might possibly do himself damage, or interfere with the administration, he should be held by an assistant, but care should be taken not to lean heavily upon the chest or abdomen. As a general rule, the cautious, but continuous application of the anæsthetic quickly causes such muscular phenomena to subside. With chloroform care must be taken, as has been fully explained, not to limit the air-supply during this so-called struggling; whereas with ether moderate air-limitation is advantageous at this period, and free from risk in persons of average strength. With nitrous oxide a rapid increase in the supply of the anæsthetic is indicated, and greater pressure should be made upon the face-piece in order that all air may be excluded.

Reflex movements may occur at all stages of anæsthesia, and occasionally give rise to trouble. As a general rule more of the anæsthetic is needed; but the administrator must bear in mind the very important fact, for the truth of which I can vouch, that the abolition of a reflex movement may possibly involve the patient in danger. In bladder operations, for example, it may be hazardous, in certain patients, to completely subdue a very slight and possibly almost imperceptible movement of the legs when the catheter touches a sensitive part of the bladder. In most cases, the anæsthetic may be unhesitatingly pushed, but not in all.[1] Should some reflex movement persist under ether, even though freely administered, the anæsthetist should change to the A. C. E. mixture or chloroform, and he will usually be gratified by the result. Generally speaking, reflex movements of all kinds are less common under chloroform than under ether, though, when the latter is administered very deeply, it is extremely rare to meet with this form of movement, even in operations upon highly sensitive parts.

Irregular muscular twitchings may be noticed under all anæsthetics: they are most commonly, I believe, of an asphyxial nature. They do not, as a rule, inconvenience an operator. They are most common under nitrous oxide when administered free from oxygen; and as children and anæmic patients are particularly susceptible to them, and as their occurrence might interfere with the efficient performance of an operation, it is best not to push the gas very far in such cases. The admission of more air, when administering ether or chloroform, usually causes these twitchings to subside. They should, I believe (p. 221), be taken as a sign for great caution when they affect the upper extremities during the use of chloroform.

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[1] In one of Dr. Sheppard's cases he found that the abolition of a reflex movement of the finger, during a perinæal operation under chloroform, was immediately followed by impaired breathing.

Fine rhythmical tremor is chiefly met with under ether, and may as a rule be stopped by a deeper narcosis. It has been considered on p. 154. I have also seen it in alcoholic patients under nitrous oxide.

Sometimes it is difficult to secure thorough and complete muscular relaxation during surgical anæsthesia, certain parts of the body remaining inconveniently rigid for a long period. With nitrous oxide, as has been pointed out, muscular flaccidity can never be relied upon. With ether, too, there is on the whole a greater tendency to inconvenient muscular rigidity than with chloroform. Time should be allowed, when employing ether, for complete relaxation to become established. A patient may be rendered deeply unconscious with this anæsthetic in a minute or two, but ten minutes or thereabouts may in some cases be required before thorough flaccidity can be said to be present. If rigidity persist after this period has elapsed—a most inconvenient condition in abdominal or bladder surgery—a few drops of chloroform should be administered upon lint: as a general rule the tonic spasm will then quickly pass away and the ether may be resumed. Rigidity will often disappear when more air is allowed with the anæsthetic, a fact which leads one to suppose that the condition may sometimes depend upon intercurrent asphyxiation. This view is borne out by the following facts:—that a relaxed muscular system is commoner under nitrous oxide and oxygen than under nitrous oxide alone: that in close methods of etherisation, the degree of rigidity often varies directly with the degree of cyanosis and other evidences of deficient blood oxygenation: and that tonic muscular spasm is comparatively rare during 'open' chloroformisation. I once observed a widespread and inconvenient rigidity of the body to co-exist with an imperfect entry of air, from the tongue being pressed against the teeth: when, by the separation of the teeth, a more free passage of air became established, the rigidity at once passed off. I have also noticed a greater tendency to rigidity when ether is administered by Clover's apparatus than when Ormsby's is used; this is probably due to the narrower channels of the former inhaler. I think it is clear that, when employing ether, we should not only give large quantities of the drug to overcome rigidity, but also an increased air-supply. Alcoholic patients, those whose muscular systems are well developed, and highly nervous or hysterical subjects may give trouble to the administrator by persistent rigidity. Whenever ether fails to relax, chloroform should be resorted to. I may here mention, however, that I once failed to secure thorough abdominal relaxation even with chloroform. The patient's average daily consumption of beer was reported to be six gallons. I found that respiration became jeopardised, and the pupils widely dilated, each time I got to the verge of abdominal relaxation. Fortunately such cases are excessively rare.

C. COUGHING.

Coughing is always associated with a slight or moderate degree of anæsthesia; it never occurs in very profound narcosis. In the early stage of administration it may depend, as is sometimes the case when administering nitrous oxide, upon a long uvula which touches the pharynx. An alteration in the position of the head at once subdues the cough. Most commonly, however, at this stage coughing is due to too pungent a vapour; and the remedy in such cases is equally clear. Patients with an irritable throat, and those who have recently smoked tobacco, are somewhat liable to cough at the beginning of the administration. The gradual exhibition of a moderately dilute vapour will, in most cases, soon overcome coughing. Other things being equal, vigorous and florid persons are more susceptible to cough during anæsthesia than feeble and anæmic patients, probably because the latter are more easily placed deeply under the anæsthetic. Speaking generally, coughing should be kept in abeyance during anæsthesia, for it is likely to inconvenience the operator in most operations, and more especially in abdominal, ophthalmic, and bladder cases. Should it be difficult to abolish the cough when using ether, chloroform should be given. As already explained, there are some cases in which an occasional cough is a positive advantage, for it keeps the air-passages free from blood (p. 36). In persons with much bronchitis, or with any affection accompanied by much pulmonary or bronchial secretion, an occasional cough is to be encouraged. Coughing is nearly always preceded by deglutition-movements, so that should the administrator desire to keep his patient free from coughing, he should narrowly watch the behaviour of the larynx.

D. HICCOUGH.

Hiccough seems to be most prone to occur when the intestines are being manipulated or operated upon. It is, however, very rarely met with. It is chiefly inconvenient in abdominal section, and in cases requiring regularity and tranquillity of breathing. Unfortunately hiccough is difficult to relieve. It occurs with ether as well as with chloroform, and is little if at all influenced by modifying the depth of anæsthesia. Should it prove highly inconvenient to the operator, the question may arise as to whether it would not be advisable to remove the anæsthetic altogether for a while. A risk of retching and vomiting would then be incurred : but the hiccough would probably disappear.

E. RETCHING: VOMITING.

Retching and vomiting, like coughing, never occur during very profound anæsthesia. They are met with either before true surgical anæsthesia has become established, or whilst the patient is emerging from the effects of the anæsthetic. It is the duty of the anæsthetist to do all in his power to prevent their occurrence whilst the patient is under his charge. Retching and vomiting are objectionable as complications of surgical anæsthesia for at least three reasons. In the first place, the movements of the patient's abdominal and thoracic parietes may embarrass the operator, or actually render the operation hazardous or impossible : in the next place, should there be food present in the stomach, its discharge during light or moderately deep anæsthesia may interfere with the administration, or endanger the life of the patient : and lastly, as already pointed out, there is with many anæsthetics, but more particularly with chloroform, a liability to syncope during the act of vomiting. To avoid the *contretemps* in question, then, the anæsthetist should give the anæsthetic as speedily as is compatible with safety, and should keep the patient deeply under its influence. An intermittent inhalation will be very liable to lead to swallowing, retching, and possibly actual vomiting.

Some patients are much more liable to retching and vomiting than others. The most liable appear to be tremulous and bloated patients of alcoholic habits ; flabby young men and women with muddy complexions ; and persons who are, as it is said, of 'bilious temperament' or liable to 'sick headaches.' Persons of spare build, as well as the aged, are not nearly so prone to vomit as those of opposite types. When large quantities of mucus and saliva are secreted, a very deep anæsthesia may be necessary in order to stave off vomiting.

Retching and vomiting are very rare at the outset of an administration, though they may take place.[1] I have met with retching, for example, at the very outset of the administration of the A. C. E. mixture to an exhausted and nervous subject, and it so interfered with the induction of anæsthesia that I had to give nitrous oxide, which I fortunately had by me, in order to proceed comfortably to etherisation.

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[1] A curious illustration of this fact once came under my notice. A friend of mine wished to try the A. C. E. mixture, as I had explained that its vapour had a fragrant and agreeable odour when not concentrated. I poured a *few drops* upon the sponge of a Rendle's mask. The inhaler had hardly been

Retching is not infrequently induced, before administering an anæsthetic for a dental operation, by the simple opening of the mouth for the insertion of a suitable prop, or by the introduction of the prop itself. Nervous patients, great smokers, and alcoholic individuals are most prone to give this trouble. To overcome it the best plan is to divert the patient's mind by inducing him to mentally count his respirations whilst breathing the gas. In this way the difficulty may usually be surmounted. Should this fail, I find the plan suggested to me by Mr. R. H. Woodhouse to answer well. He employs a gargle of a rather strong solution of carbolic acid (about 1 in 60), after the use of which the patient can usually tolerate the presence of a mouth-gag without discomfort. Should these measures fail, a very small prop must be used, or the gas administered without employing any means for keeping the teeth apart. Under such circumstances as these, a Mason's gag must be introduced immediately the face-piece is removed.

When once the patient has been placed fairly under the influence of the anæsthetic, the administrator should have no difficulty in averting vomiting. He must watch for the early indications of its approach, and at once increase the depth of anæsthesia. Amongst these indications swallowing is the best guide. Sometimes, however, a high-pitched inspiratory sound may indicate a tendency to vomit; or a shallow form of breathing, with some pallor but with good conjunctival reflex, will be equally suggestive; or, lastly, an increase in the size of the pupil may help as a guide, though, if the administrator has been on the alert, he will probably have received earlier warning from other signs.

When it is quite obvious that the vomiting cannot be stopped, the administrator should at once turn the head to the side (if it is not already so placed), and raise the opposite shoulder. The teeth usually become clenched at this stage, and little or no air enters the chest as the larynx is, of course, closed. The lower

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applied to the face before sudden vomiting occurred. Food had been taken just before the experiment. This was probably a purely reflex effect, produced by the contact of vapour with the mucous lining of the air-tract. I mention the occurrence because it serves, I think, to explain other cases, and because fright and apprehension were wholly absent, and could not therefore have contributed as factors.

jaw should be pushed forwards from behind, and in a few moments the duskiness will pass off without difficulty. I have never seen any trouble arise, even when undigested food has been present in the stomach, by allowing vomiting to take its own course with the head in this position. Sometimes gently wiping the lips or passing in the finger will expedite matters. Should the patient be feeble, it is not desirable to allow suspended respiration of any duration to persist, and the teeth must be separated. Should it be necessary, the mouth may be sponged out, or the finger passed to the back of the throat to make sure that everything likely to cause obstruction has come away.

In cases of intestinal obstruction special care (as already mentioned) is necessary in the management of vomiting.

The minor difficulties connected with respiration and circulation will be considered in the two following chapters.

CHAPTER II.

THE MANAGEMENT AND TREATMENT OF THE DIFFICULTIES, ACCIDENTS, AND DANGERS CONNECTED WITH RESPIRATION.

We have now to consider a very important branch of the present subject, viz., the management and treatment of the difficulties, accidents, and dangers which may arise in connection with respiration during the anæsthetic state. Safe and satisfactory anæsthesia can only be maintained so long as respiration is being efficiently performed. It is hence necessary to keep a vigilant watch for the slightest indications of respiratory feebleness or embarrassment, and at once to correct such conditions, in order to prevent the occurrence of more serious troubles during the administration.

Having fully considered in the preceding parts of this work the various circumstances which may modify or interfere with respiration during surgical anæsthesia, we have laid the groundwork, as it were, upon which we may now construct a system of treatment capable of application to every case which may come under our care.

When administering an anæsthetic for a surgical operation the anæsthetist may meet with, and have to treat, difficulties of respiration belonging to one or both of the following groups—

(1.) Difficulties in, or failure of, respiration due to the presence of some mechanical obstruction to the free entry or exit of air. (*Vide infra:* Sect. I.)

(2.) Feebleness or failure of respiration occurring independently of any mechanical obstruction. (*Vide infra:* Sect. II.)

It will therefore be convenient to consider these two conditions separately.

Section I.

DIFFICULTIES IN, OR FAILURE OF, RESPIRATION DUE TO THE PRESENCE OF SOME MECHANICAL OBSTRUCTION TO THE FREE ENTRY OR EXIT OF AIR.

A. ALTERED POSITION, SPASM, OR SWELLING OF PARTS WITHIN OR ABOUT THE UPPER AIR-PASSAGES.

General Summary.—The importance of maintaining a free air-way during anæsthesia needs no comment. It is a curious fact, however, that very little attention has been bestowed upon this point. An anæsthetic is given, and the patient is said to 'take it badly,' or to 'breathe badly,' but the cause of the difficulty in breathing is rarely accurately defined. There is a tendency for all anæsthetics to indirectly or directly cause obstructed respiration—a fact which should ever be borne in mind; and this tendency is the greater when any pre-existing narrowing of the air-passages is present. The air-way may become obstructed at various places. The nature and degree of the impediment will vary with many factors, *e.g.*, whether the patient was breathing wholly or partly through his nose or mouth before the obstruction occurred; the position of the head, and more especially that of the lower jaw; the size and conformation of the patient's air-tract; and his general muscular development. Breathing during deep anæsthesia usually takes place through the nose. It may, however, take place through the mouth. Or inspiration may take place through the former, and expiration through the latter channel, the soft palate acting as a valve. The various pre-existing morbid states which may favour obstructed breathing have already been discussed, and the reader is referred to p. 22 for remarks on this head. Apart from such affections, and apart also from the presence within the air-passages of adventitious substances, the following are the chief obstructions to breathing which may arise.

In the first place oral respiration may become obstructed—by the **lips** being pursed up or falling together: by the **tongue** coming into contact with the teeth: or by the **soft palate** and tongue meeting. Spasm of the masseters often contributes to the completeness of the occlusion.

In the next place, the nasal air-way may become occluded during the administration, more especially if previously narrowed by some morbid condition. Thus, the **alæ nasi** may fall together during inspiration: or the **nasal mucous membrane** may become so swollen that the air-way through the nose is rendered unavailable: or the **soft palate** may, by contact with the pharynx, completely shut off the nose as a respiratory channel.

Then, again, we find that the **base of the tongue** may, under certain circumstances, come into contact with the pharyngeal wall. This is a very common cause of stertor and temporary obstruction to respiration.

Furthermore, the larynx may become covered by the **epiglottis** in the course of tardy deglutition movements; or this form of obstructed breathing may arise independently of swallowing, as for example, when the administration of nitrous oxide is pushed to an unnecessary degree.

Lastly, breathing may become obstructed either by closure of the folds at the **superior aperture of the larynx**, or by contraction of the sphincter muscles of this organ.

A few remarks on **stertor** may not be out of place in this connection. Strictly speaking, the word should be applied only to snoring sounds; but it is often used to describe others of different character. Dr. R. Bowles has devoted much attention to stertor, and in his recent work on the subject[1] describes the following varieties:—

(1.) *Nasal.* Approximation of the alæ nasi towards the septum, as in 'sniffing.'

(2.) *Buccal.* Lips and cheeks puffing and flapping during expiration and inspiration.

(3.) *Palatine.* Soft palate vibrating. Breath may either pass through nose or mouth; the palatine stertor thus acquiring a nasal character in the one case, and an oral character in the other.

(4.) *Pharyngeal.* Produced by the base of the tongue vibrating against the pharyngeal wall.

(5.) *Laryngeal.* Vibrations of the vocal cords.

(6.) *Mucous.* Presence of mucus in trachea and larger tubes.

All these varieties are met with in patients under anæsthetics; and we are indebted to Dr. R. Bowles for having so clearly and ably drawn attention to the importance of stertor. He rightly insists that stertor is in itself indicative of a tendency to obstruction: and there can be no doubt that very profound stertor should be regarded as an indication for caution and, in many instances, for a somewhat less free use of the anæsthetic.

With regard to the first-named variety, Lisfranc states that he has seen obstructed breathing occur from the falling together of the thin walls of the nose during inspiration, and has found it necessary to keep the nasal channel artificially open.

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[1] 'On Stertor and Apoplexy,' by Robert L. Bowles, M.D., 1891.

Buccal stertor is common in edentulous old persons, and may either be prevented by fully extending the head to encourage wholly nasal respiration, or by keeping the gums apart by a mouth-prop.

Palatal stertor is said to be one of the most frequent kinds of stertor during anæsthesia; but this is questionable. From the almost invariable stoppage of stertor which follows the pushing of the lower jaw forwards, it is more probable that pharyngeal stertor, which results from the tongue touching the pharynx, is the commonest.

The tongue, as I have elsewhere particularly pointed out,[1] often becomes greatly engorged and very large during anæsthesia. It not infrequently projects a considerable distance between and beyond the teeth. In such cases pharyngeal stertor is met with, and may tend to pass into obstruction if the jaw be not kept well forwards.

Laryngeal stertor, which has yet to be more thoroughly investigated, is of special interest to the anæsthetist. That obstructed breathing is often caused by partial or complete laryngeal occlusion there can be no doubt. The word stertor, however, does not convey a proper idea of the sound produced. Continuous and high-pitched inspiratory stridor is common both with ether and with chloroform, and embarrassment to, or actual cessation of, breathing may take place as the result of the condition upon which this sound depends. As the pitch of the sound grows higher, so the obstruction becomes more pronounced. In most cases the laryngeal spasm is associated with an imperfectly developed anæsthesia, rather than with the administration of too strong a vapour. It sometimes commences immediately a very sensitive part of the body, *e.g.*, the rectum, is manipulated. On other occasions it appears to indicate the approach of coughing or vomiting; for, if the anæsthetic be withheld one or other of these events may occur, and the sound will then pass off. And, lastly, laryngeal spasm appears to be, in some instances at least, brought about by air-deprivation. The administrator may have difficulty in deciding what course to adopt when this high-pitched crowing sound comes on, and less and less air is gaining access to the lungs. In the very early stages of the administration, *i.e.*, before surgical anæsthesia has become established, it is best to stop the administration till the spasm has passed away;[2] but should the patient have been for some time deeply narcotised when the crowing comes on, an attempt should be made to overcome the condition by giving more of the anæsthetic. Should the crowing fail to quickly subside when more of the anæsthetic is given, the opposite treatment should be adopted, and the stridor allowed to pass away by itself. It may happen that the high-pitched crowing sound is attended by so much duskiness, and suspension of respiration, that it is impossible to do other than wait until the condition has passed off. I have notes of a case in which laryngeal spasm under ether led to fine clonic movements of the arms and hands, doubtless asphyxial in origin. Complete cessation of breathing from the cause under consideration is more common under chloroform than under ether, and far more hazardous to life. Sir Joseph Lister specially directs attention to the importance of prompt treatment in the case of chloroform. With ether the breathing rarely actually ceases as the direct result of laryngeal spasm. The interesting observation originally made by Dr. Hooper of Boston, and corroborated by Dr. Semon and Professor Victor Horsley,[1] is worthy of consideration. Dr. Hooper found that, in dogs deeply under ether, stimulation of the recurrent laryngeal nerve caused abduction of the cords, whereas if only a light degree of etherisation was present, adduction resulted. We certainly find in practice that, unless the anæsthesia be very profound, the larynx is highly susceptible, not only to local but to distant stimuli, so that if laryngeal troubles are to be avoided ether must be used freely. High-pitched crowing laryngeal sounds under nitrous oxide are never met with, except in association with vomiting or the presence of some foreign matter in or near the larynx itself. (For further remarks see pp. 160 and 221.)

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[1] *Trans. Roy. Med. Chir. Soc.*, vol. lxxiv. 1891, p. 107.

[2] Dr. V. Poore, in a very able article on chloroform administration (*Lancet*, vol. ii. 1872, p. 521), recommends this course, and regards the sound as a sign of danger. The condition is not referred to by Kappeler.

Treatment.—Although obstructed breathing during anæsthesia may arise, as above indicated, in numerous ways, the treatment which should be adopted for its relief is extremely simple. In nine cases out of ten all forms of obstructed breathing may easily be overcome by simply **pushing the lower jaw forwards from behind**, as shown in Fig. 54, which represents the position in which the fingers of the administrator should be placed whilst his patient is deeply under ether. The head should be kept well on its side, and the lower jaw pressed well forwards from behind. To effect the latter, the forefinger of the anæsthetist should be placed in the hollow below and in front of the mastoid process, and force should be applied to the ascending ramus of the lower jaw along a line drawn from the mastoid process to the angle of the mouth. Sometimes the upper front teeth will, by overlapping the lower, prevent the lower jaw from being pressed forwards, in which case the teeth must be disengaged before breathing can be freely re-established. Sometimes, too, there is so much spasm of the masseters and other jaw-muscles, that it is difficult, unless considerable force be brought to bear on *both sides*, to move the lower jaw forwards. The beneficial effects of the procedure are due to the tongue and epiglottis being carried forwards, *i.e.*, away from the pharynx and larynx respectively. When the mouth is opened, the base of the tongue, as pointed out by Dr. R. Bowles, is nearer to the pharyngeal wall than when the mouth is closed. With a closed mouth, indeed, the interval between the tongue and the pharynx is usually perfectly sufficient for free respiration. But should the tongue and adjacent parts be engorged, or should the parts be thoroughly relaxed and the head in the middle line so that the tongue gravitates downwards, this interval may cease to exist, and some such manœuvre as that just described will be necessary in order to re-open the air-way. The epiglottis is also brought away from the pharynx by pushing the lower jaw forwards, as I have actually seen, by means of the laryngoscope, in a patient with temporarily embarrassed respiration under ether. It is hence clear that so long as the lower jaw can be moved forwards, and so long as the nasal passages are free, obstructed breathing may be quickly and efficiently relieved by the simple measure described. **Pulling the chin away from the sternum**[1]

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[1] 'On an apparently Peripheral and Differential Action of Ether upon the Laryngeal Muscles' (*Brit. Med. Journ.*, Aug. 28, 1886, p. 405).

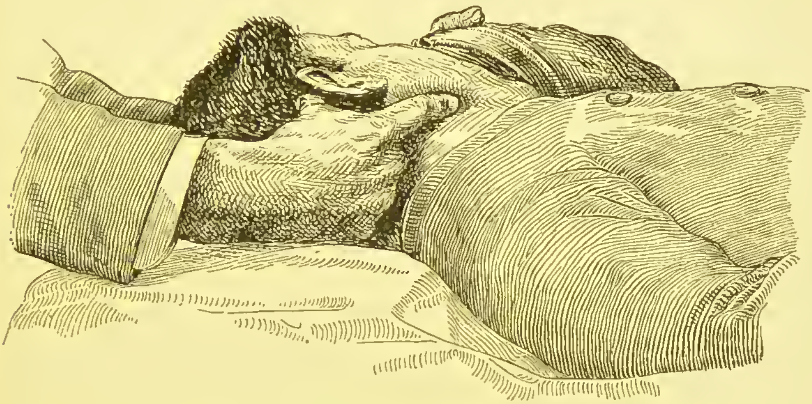

FIG. 54.—The Finger of the Administrator pushing the Lower Jaw Forwards. (From a photograph.

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[1] This was recommended by Clover, as a useful procedure, as far back as 1874. See *Brit. Med. Journ.*, Feb. 14, 1874, p. 201. Mr. Clover made the following important remarks :—" The act of swallowing is usually performed well enough ; but, if the anæsthetic have produced sufficient effect upon the

has a similar effect to that produced by pushing the lower jaw forwards, but is not to be fully relied upon. **Complete extension of the head and neck** has also been recommended for the relief of arrested breathing; but whilst such a procedure is undoubtedly easy of application and quite efficient, so far as opening up an air-way is concerned, in a dead subject, it is not trustworthy in actual practice.

But certain cases will remain in which the obstruction cannot be removed by any of the above-mentioned measures. It then becomes necessary to **open the mouth.** Should the teeth be tightly clenched this must be effected by some form of mouth-opener. I find the best and simplest plan is to insert the long wooden wedge shown in Fig. 2, p. 82. Its thin end can be introduced without delay, even between the most tightly clenched jaws; and after it has been insinuated far enough the Mason's gag (Fig. 1, p. 82) should be inserted. When there are vacant spaces between the teeth, a Mason's gag will itself suffice. Care should always be taken not to injure or dislodge any fragile teeth. Opening the mouth at once disposes of any difficulty arising from nasal obstruction. **The finger should now be passed to the back of the throat, a momentary examination made, and the base of the tongue should then be hooked forwards by the finger.** Should this not succeed the **tongue forceps should be applied** and vigorous traction made. Any impediment due to the tongue will now be overcome. Moreover, there is, as pointed out by Sir Joseph Lister, a form of obstruction at the superior aperture of the larynx, which is also relieved by tongue-traction. (See Illust. Case, No. 29, p. 294.) This obstruction is not due to the epiglottis, but to the falling together, or spasm, of the folds at the superior aperture. Tongue-traction will not of itself remove the epiglottis from the larynx, unless indeed the tongue should be so forcibly dragged forwards that the lower jaw is dragged with it. Epiglottic obstruction, as has been explained above, may usually be relieved by pushing the lower jaw forwards from behind. Should breathing still continue in abeyance after the measures described, the administrator should **forcibly compress the sternum and thoracic parietes** with the object of forcing the gaseous contents of the chest past any laryngeal obstruction. I have known this measure to succeed when those above described have failed. It is quite possible, in some cases in which the epiglottis is the cause of obstruction, that the

patient to interfere with reflex movements, then the deglutition may be delayed at the moment when the epiglottis covers the larynx. Raising the chin, and pulling it as far as possible away from the sternum, is usually sufficient to obviate this source of obstruction."

natural but fruitless efforts at inspiration may suck this body so tightly over the laryngeal orifice that it cannot be released by the ordinary means. The finger may, of course, be used to raise it in favourable cases. Should the obstruction be below the epiglottis, **intubation**[1] may be attempted by any one skilled in throat surgery. Unless the administrator is quite conversant with the subject, however, he may find difficulty in applying either of these measures. If pushing the lower jaw forwards, extending the head and neck, vigorous tongue-traction, attempting to raise the epiglottis by the finger, endeavouring to pass a catheter into the larynx, and forcibly compressing the chest walls, should all fail to overcome the obstruction, **laryngotomy** or laryngo-tracheotomy should be performed without delay.

During last year the idea occurred to me that it might be possible, by inflating the intestines *per rectum* with oxygen, to successfully treat those cases in which breathing comes to a standstill from some mechanical impediment. Dr. Starling of Guy's Hospital, and Mr. George Rowell very kindly and carefully conducted for me several experiments upon an asphyxiated dog. The animal was placed under chloroform and morphia and then curarised. Its trachea was opened and a tube inserted, through which artificial respiration was kept up by automatic bellows. Its carotid blood pressure was recorded during the experiments. Asphyxia was brought about by stopping the artificial respiration. When the blood pressure had fallen considerably, oxygen was introduced in large quantities into the rectum until the intestines became fully distended. Unfortunately no effects whatever followed. I mention the experiment, as it is of negative value.

I propose to give a few illustrative cases from my notebooks :—

Illustrative Case, No. 28.—M., æt. about 22. Pale : neck much enlarged both sides by sub-maxillary glands : no nasal respiration, probably from presence of adenoid growths. Operation for removal of cervical glands. Teeth kept apart by preliminary insertion of small piece of cork. Ether administered by Clover's inhaler. Respiration difficult. Unable to keep lower jaw pressed forwards by reason of its being deeply embedded in the glandular swelling. Tongue much engorged. A. C. E. mixture tried : no better result. The difficult respiration obviously depended upon the tongue obstructing the oral air-way. Had to keep base of tongue hooked forwards by finger. Eventually had to keep tongue pulled continuously forwards by means of tongue forceps, and to administer chloroform on the end of a Skinner's mask. By this means respiration became free and all difficulty vanished. Administration lasted one hour.

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[1] Kappeler (p. 132) advises the introduction of a laryngeal catheter in these cases.

The above case illustrates the impossibility, in some instances, of pushing or dragging the lower jaw forwards. The difficulty of breathing was due to this cause, for the base of the tongue rested against the pharynx and could not be brought away by the usual means.

Illustrative Case, No. 29.—F., æt. about 35. Healthy in appearance. Good chest expansion. Quick but good heart's action. Operation for ruptured perinæum. Duncan & Flockhart's chloroform: drop bottle: Skinner's mask. In seven to nine minutes from commencement of administration pupils moderately contracted (about ● = 2½ mm.), breathing quiet and non-stertorous, pulse and colour good. Operation commenced. On several occasions high-pitched crowing inspiration was noted, even though corneæ insensitive and patient apparently well under. The difficulty was overcome by giving more chloroform and pushing lower jaw well forwards. On one occasion, however, this plan failed, and the mouth had to be opened and tongue forceps applied. This restored breathing, but the colour remained pale and dusky afterwards. Ether now given on an open inhaler. Pulse and colour gradually improved, and satisfactory anæsthesia was maintained without any difficulty for half-an-hour. The operator found, however, that the parts were far more vascular under ether than under chloroform, so the latter anæsthetic was again tried. Precisely the same respiratory difficulty as before appeared. The operation, however, was by this time just finished. The crowing breathing subsided altogether directly the manipulations about the perinæum were discontinued.

The above case is of considerable importance as illustrating the occurrence of what may be termed reflex laryngeal obstruction during the use of chloroform. Florid young and middle-aged adults seem particularly liable to the condition under chloroform during such operations as that mentioned, and the only treatment which is of any avail in obstinate cases is forcible tongue-traction. It is a remarkable fact that this form of obstructed breathing under ether is practically unknown. I am quite ready to admit that, in the above case, the condition would probably have been avoided by a more profound anæsthesia, that is to say, by a more liberal use of chloroform.

Illustrative Case, No. 30.—M., æt. about 40. Bloated, flabby, and very alcoholic. Short stature, short neck, large abdomen. Extremely nervous and tremulous. The lower jaw embedded, as it were, in thick flabby tissues, the patient having a 'double chin.' Good teeth. Operation, removal of small tumour in mammary region. Decided to administer ether preceded by a small quantity of the A. C. E. mixture. (See p. 256.) A. C. E. given gradually on Rendle's mask. Respiration good. No struggling. Some rigidity coming on, Ormsby's inhaler charged with 'pure methylated ether' was applied gradually. Respiration at first fairly free, but in a short time some spasm about the jaws came on, and rather suddenly drew the head somewhat forwards so that the chin approached the sternum. This at once stopped breathing. Could not press jaw forwards from behind owing to thick neck: and forcible extension of the head and neck equally impossible because of extreme muscular rigidity. Mouth opened: Mason's gag introduced: and forcible tongue traction made. Respiration at once became re-established, and normal colour of face returned. No further difficulty beyond that great care had to be exercised to keep an air-way open.

The above case illustrates the difficulties which may arise in anæsthetising a patient of the type described, and the manner in which such difficulties should be treated. No matter what anæsthetic be chosen, fat and flabby subjects, presenting the appearance I have attempted to portray, will always be liable to give trouble to the anæsthetist during the stage of muscular spasm. The sudden arrest of breathing (before the patient was really properly anæsthetised) was doubtless due to spasm of some of the neck and jaw muscles, such as the sterno-mastoid, mylohyoid, &c., the contraction of which suddenly brought the head forwards and the chin downwards, thus throwing the base of the tongue against the pharyngeal wall. In patients of a different type to that described, the obstructed breathing may at once be corrected by the procedure figured on p. 291, by pulling the chin away from the sternum, or by extending the head and neck. But in certain individuals neither of these procedures may be possible, and tongue traction will hence become necessary.

Illustrative Case, No. 31.[1]—M., æt. 35. Middle height: well nourished: rather florid. Present general condition good, but has had many rheumatic attacks which have left him with articular disease and stiffness in many parts of body. Neck rigid. Can only open mouth about one quarter of normal extent owing to chronic rheumatoid disease of articulations of jaw. Nitrous oxide administered for tooth extraction. Usual method adopted. Small mouth-prop inserted before face-piece applied. The usual phenomena of nitrous oxide narcosis presented themselves. Tooth extracted. The nitrous oxide had been pushed till respiration underwent the characteristic change in rhythm; but the admission of air which followed the removal of the face-piece failed to restore the rhythm of breathing. Instead of respiration becoming re-established and the normal colour returning, breathing became more difficult and quickly ceased as if from some obstruction. It was impossible to push the lower jaw forwards because of its fixity, or to extend the head and neck owing to the rigid and ankylosed spine. The finger could not be passed to the back of the throat by reason of the small aperture between the teeth. Tongue traction was at once made, but failed to restore breathing. Compression of the thoracic walls was equally unsuccessful. The patient was placed upon the floor and forcible pressure was brought to bear on the sternum, but the thorax was immovable. The face was cyanosed and bloated, the lips purple, the whole body rigid, the chest motionless and fixed. Breathing had been suspended for about 2 or 2½ minutes, according to my reckoning; but it is difficult to speak positively on this point. It was obvious that the only remedy left was laryngotomy. Having my tracheotomy instruments with me I rapidly opened the crico-thyroid membrane with a pocket-knife and inserted a tube. Breathing at once recommenced. The patient made an uninterrupted recovery.

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[1] I published this case in detail in the *Journ. Brit. Dent. Association* for 1888, vol. ix. p. 222.

I have introduced the above case as it is of considerable interest. The obstruction to breathing was almost certainly at the suporior aperture of the larynx. As has been shown (p. 104), when nitrous oxide is administered to its full extent, the larynx is often drawn up, as in deglutition, to meet the epiglottis. Should the temporary obstruction thus brought about not pass off spontaneously, as it usually does, all that is necessary in ordinary cases is to push the lower jaw well forwards from behind, which brings the epiglottis away from the larynx and restores breathing. But in this remarkable case this manœuvre was impossible, owing to the almost complete fixity of the jaw. Traction upon the tongue was equally unsuccessful; for, as we have seen, the epiglottis cannot be moved in the slightest degree by pulling the tongue forwards. The narrow space between the upper and lower teeth prevented tho finger from being introduced with the object of removing the epiglottis. And, lastly, the cervical spine being ankylosed, the head could not be extended. Had it been possible to completely extend the head and neck, the obstruction would probably have been overcome. Laryngotomy was fortunately successful in rescuing the patient from imminent death.

B. ADVENTITIOUS SUBSTANCES WITHIN THE AIR-PASSAGES.

There are numerous adventitious substances, both liquid and solid, which may find their way into the air-passages during anæsthesia and give rise to respiratory difficulties. Amongst them may be mentioned:—

1. Blood.
2. Vomited matters.
3. Mucus.
4. Pus.
5. Portions of morbid growths.
6. Extracted teeth, fragments of teeth, or stoppings.
7. Artificial dentures and pivoted teeth.
8. Portions of, or entire mouth-props or corks.

9. Portions of instruments used in laryngeal, dental, or similar operations.

10. Pieces of sponge not firmly secured upon holders.

11. A 'quid' of tobacco[1] which was present in the mouth before the administration has also been known to cause asphyxial symptoms during anæsthesia.

Blood.—The cases in which blood is liable to obstruct respiration have already been considered (p. 36). It is only necessary to add. in this connection, that epistaxis[2] may arise during the use of anæsthetics, and even hæmoptysis has been known; but such complications are of great rarity. Blood may cause obstruction to breathing at any part of the air-tract, from the nasal or oral cavities to the smaller bronchi. The symptoms of the patient will necessarily vary with his position during the accumulation of the blood, the quantity of blood present, and the depth of anæsthesia. As already indicated, blood may be present, and to a considerable degree, in and below the larynx, with but few symptoms. When the anæsthetic is withdrawn, coughing usually dislodges the blood, which is either swallowed or forcibly ejected from the mouth, and no further trouble occurs. A sudden rush of a large quantity of blood into the larynx, however, during a deep inspiration, would quickly bring respiration to a standstill, the fluid finding its way into the larynx, trachea, and possibly the bronchi. This, however, is a rare contingency. More generally the larynx and trachea become increasingly obstructed by blood and blood-clot, and the air-way narrowed; and it is at this stage that the patient's condition attracts attention and demands treatment. In other cases blood finds its way, in small quantities at a time, into the trachea, and thence into the larger and smaller bronchi, being sucked down from above by the inspiratory movements of the patient.

As already pointed out (p. 36), preventive measures are the best in the treatment of these difficulties. It has been shown that the patient's head should be kept, as far as is possible, in that position which is most favourable to the escape of blood: that too deep an anæsthesia should be avoided: and that the pharynx should be well sponged out as occasion may require.

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[1] Fischer, *Deutsche Zeitsch. f. Chir.*, Bd. xv. 1SS.

[2] I have met with one case of epistaxis under ether, in a young man of about 24. In Dr. Sheppard's notes I find another case recorded in which epistaxis occurred under chloroform. In the latter case the patient was a man of 62, and the epistaxis came on after struggling. A moist râle in the trachea was the first indication of the bleeding. On looking into the mouth a good deal of clotted blood was discovered. Hæmoptysis is very rare. I have never met with it, though I know of one case in which it occurred, to a slight extent, under ether.

Should these precautionary measures be not adopted—and it is not always easy or possible to adopt them—signs of obstructed respiration will probably assert themselves. The colour will grow more and more dusky, the breathing laboured and stridulous, a characteristic bubbling sound will be heard in the larynx or trachea, and unless proper steps be taken respiration may cease. When such symptoms appear, the anæsthetic should be withheld; the patient turned upon his side; the pharynx sponged out by frequent sweeps of a sponge over the aperture of the larynx; and the tongue should be drawn well forwards. Should breathing threaten to cease, or actually come to a standstill, the chest should be forcibly compressed. This compression will often force out blood from the larynx, and cause the symptoms to subside. Sponging should not be omitted, as the sponge will sometimes entangle a long laryngeal clot in its meshes. If these means fail, systematic artificial respiration, by Silvester's plan, should be tried; and, provided that the artificial movements drive air past the obstruction, the procedure should be continued. In cases which fail to quickly respond to artificial respiration, laryngotomy must be promptly performed; the end of the bed or operating-table raised to facilitate the escape of blood from the trachea or bronchi, and, after a preliminary compression of the chest walls, artificial respiration commenced. If air still fail to enter the chest a catheter should be introduced, and any blood sucked away. In very exceptional cases (*vide infra*), artificial respiration may fail to give relief, even though there is a free air-way from the laryngeal opening to the lungs. In such cases the indication appears to be forcible inflation of the chest. If a cylinder of oxygen with an india-rubber bag and tube is at hand, a catheter should be connected to the last-named, and an attempt made to inflate the lungs. Or if an ordinary pair of bellows be available an attempt may be made to drive air into the chest.[1]

Vomited Matters.—Numerous cases are on record in which, during anæsthesia, vomited matters have been drawn into the larynx and trachea by an inspiration on the part of the patient, and have thus caused fatal asphyxia.[2] As we have already seen, vomiting is of very common occurrence with most anæsthetics; and should the stomach contain undigested solid food there is always some risk connected with the expulsion of the contents of this organ. A proper regulation of the diet is not always possible, and there are, moreover, certain cases, *e.g.*, those of intestinal obstruction, in which vomiting is a feature of the malady which necessitates operation. In such cases every care must be exercised by the administrator. The head should never be permitted to pass into the mid-line; it should be kept upon its side throughout. A little mouth-prop may with advantage be placed between the teeth, in order to allow of a free egress for the vomited matters when emesis takes place. The closure of the jaws which would otherwise occur, and which might be the source of trouble, will thus be prevented. Directly vomiting comes on, it is a good plan to partially or completely turn the patient upon his side. Should any difficulty arise, the mouth may be opened, and the finger passed to the back of the throat to clear away any obstructing material. Large solid portions of meat, vegetables, &c., may be thus removed. Should the finger be able only to touch the intruding substance, a pair of curved forceps may be used with advantage. Sponging should only be resorted to in the absence of solid material. If the breathing become seriously impeded, and if the above measures fail to restore it, an attempt should be made by compressing the sides and front of the chest, to force out air past the obstruction. If, however, artificial respiration should fail, laryngotomy must be resorted to.

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[1] For Illustrative Cases see *Brit. Med. Journ.*, Feb. 24, 1883, p. 352 (two fatal cases recorded). Also *Lancet*, Aug. 27, 1881, p. 386. Also *Brit. Med. Journ.*, Sept. 16, 1882, p. 531; and *Lancet*, Sept. 30, 1882, p. 540.

[2] Of the 101 chloroform fatalities reported by Kappeler two were due to this cause. For Illustrative Cases see *Lancet*, Sept. 30, 1871, and *Brit. Med. Journ.*, same date; *Edin. Med. Journ.*, vol. viii.; two cases reported by Socin in the *Tageblatt der Naturforscherversammlung*, 1879, No. 7; *New York Med. Journ.*, Oct. 20, 1883, p. 448 (two cases referred to); *Lancet*, Oct. 3, 1874, p. 504; *Brit. Med. Journ.*, Sept. 16, 1876, p. 381; *Brit. Med. Journ.*, Feb. 24, 1883, p. 351; *Brit. Med. Journ.*, Sept. 3, 1881, p. 414. A case is also referred to by Dr. Jacob in the *Brit. Med. Journ.*, Feb. 23, 1884, p. 351.

Mucus.—Mucus, even though very copiously secreted, rarely gives rise to respiratory embarrassment.[1] All that is necessary is to sponge it away occasionally from the fauces, and to keep the head on the side. Should the patient commence to show signs of impeded breathing the anæsthetic should be withheld; and as the power of swallowing and coughing returns all difficulties will subside.

Pus.—There is nothing worthy of special notice regarding the presence of pus within the upper air-passages. It may gain access in various ways; and any difficulties connected with its presence must be treated as described above.

Portions of Morbid Growths, Pieces of Necrosed Bone, &c.—These may become dislodged during certain operations within the nose, mouth, naso-pharynx, and larynx, and may obstruct breathing; but there is nothing worthy of special reference concerning the symptoms which would result.

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[1] In the *Brit. Med. Journ.*, Nov. 18, 1882, p. 994, a case is reported in which a child of 17 months died under chloroform. At the autopsy large quantities of mucus were found at and below the bifurcation of the trachea. It is questionable, however, whether this condition was really the cause of death.

Extracted Teeth, Fragments of Teeth, and Amalgam or other Stoppings.—These are liable, during dental extractions, to fall or fly from the forceps of the operator. Bicuspid teeth are particularly prone to shoot from the forceps whilst being extracted. In most cases no harm results from the escape of such substances either into the mouth or throat. But there is nevertheless need for the greatest caution during the use of anæsthetics in dental surgery, seeing that several cases are on record in which alarming and even fatal symptoms have arisen from the entrance of foreign bodies of this class into the larynx or trachea. The accident seems to have taken place, in most cases, during a deep inspiration. The head of the patient should be arranged as vertically as the nature of the operation and the requirements of the operator will permit; for when the head is thus placed, all substances which may escape from the forceps will tend to gravitate towards the tongue or floor of the mouth, from which situations they may be immediately removed. It is true that, should any tooth or fragment of tooth find its way into the pharynx, there will be a somewhat greater chance of its entering the larynx when the head is vertically placed than when it is thrown well backwards. In the last-named position any loose substance would tend rather to enter the pharynx and to be swallowed than to find its way through the rima glottidis. But as the chances of loose teeth, &c., finding their way to the back of the throat are very largely reduced by keeping the patient's head more or less vertical in the chair, this position is probably the best. If a tooth, stump, or fragment should escape into the pharynx, and if it should not be immediately swallowed, it may remain for a considerable time in the epiglottic region, and may ultimately pass into the œsophagus or be forced away by coughing. Shell-like fragments of teeth are more prone than weightier bodies to enter the larynx, owing to their being more easily swept along by the inspiratory current. Should any of the foreign substances under consideration gain access to the larynx or trachea during anæsthesia, some symptoms will, in all probability, occur at the time of entry. Generally speaking, coughing of a spasmodic character is excited; and this may at once dislodge the substance. Sometimes the coughing is so slight as to escape notice. In other cases the foreign body lodges in the larynx and sets up urgent symptoms, such as stridor, cyanosis, and complete cessation of breathing.[1]

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[1] In a case reported by Mr. Claremont in 1858 (*Lancet*, May 15, 1858, p. 477), some fragments of teeth entered the larynx during chloroform anæs-

During the extraction of teeth under anæsthetics the operator should be most careful to leave nothing whatever loose in the mouth. He should remove each tooth or stump as it is extracted, and should see that there is nothing hanging to the forceps when that instrument is re-introduced. When several upper roots have to be extracted, the plan of protecting the back of the throat with the corner of a cloth is an excellent one, and should certainly be more widely adopted than it is at present. The advantages of a more or less vertical position of the head have been referred to above. Although the avoidance of accidents of this kind should rest with the operator, the administrator may often assist the latter. Thus it is possible for the administrator to place a finger across the back of the mouth between the tongue and palate; or to press the tongue against the palate and so shut off the oral cavity from the pharynx. The use of the oral net-spoon has already been mentioned (p. 86).

Should symptoms pointing to the entrance of a foreign body, such as a stray tooth, into the larynx manifest themselves, the patient should be bent forwards in the operating-chair, and his behaviour narrowly watched. The spasmodic cough and other symptoms may now quickly subside, the foreign body being either coughed into the mouth, swallowed, or so placed in the air-passages that for a while it sets up very few symptoms. Should coughing, duskiness, and difficulty of breathing continue, the back may be smartly slapped, whilst the patient is bending forwards. Should this not succeed, the patient may be turned on his side with the object of facilitating the exit of the substance. Failing this, inversion should be adopted. This last named procedure, although open to the objection that it may cause the foreign body to be coughed into the larynx, where it may

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thesia. When the patient became conscious, after the operation was over, coughing occurred, and a complaint was made of some soreness about the chest. There were, however, at the time, no distinct symptoms of the presence of the fragments. General bronchitis followed. Subsequently the fragments were coughed up from the lungs and the patient made a good recovery.

A case is also mentioned in the *Dublin Med. and Chem. Journ.* for 1834, in which "the root and fangs of a lower molar" entered the right bronchus during extraction. Death supervened in eleven days.

Another case is quoted in the *Edin. Journ.* for 1834, in which an entire lower molar entered the lung. It was coughed up on the eleventh day, and the patient recovered.

In the *Brit. Journ. Dent. Science*, vol. xxii., Jan. 1879, p. 7, a case is related in which a large amalgam stopping shot from a tooth during extraction under nitrous oxide, and presumably entered the larynx. Fortunately the patient coughed it out immediately after the effects of the anæsthetic had passed off.

See also *New York Med. Record*, Nov. 4, 1882, p. 517. Also *Trans. Odont. Soc.*, vol. iii., new series, p. 36.

induce spasm, has answered in several cases, and should certainly be tried if the symptoms are of sufficient urgency. Should signs of laryngeal spasm (high-pitched stridulous breathing, deep cyanosis, embarrassed and ultimately suspended breathing) supervene, no time should be lost in opening the larynx at the crico-thyroid space, and, if necessary, performing artificial respiration through the opening thus made.

Other Substances.—The other substances on the list, viz., artificial dentures and pivoted teeth, portions of or entire mouth-props or corks, portions of instruments used in laryngeal, dental, or similar operations, pieces of sponge, &c., if by chance they should gain access to or become impacted in the larynx, will set up symptoms of an asphyxial character which require very prompt measures. An interesting, though unfortunately fatal case,[1] in which an artificial denture became impacted in the larynx, occurred in 1872, and is well worthy of notice. An unattached mouth-cork has been known to slip from between the teeth and asphyxiate a patient under nitrous oxide.[2] The spring of a Buck's gag has also been known to enter the larynx and eventually lead to a fatal result. These facts should teach us how necessary it is to see that all dental mouth-gags are firmly secured by string or whip-cord; and also that all spring-gags should be avoided in dental surgery (see p. 85).[3]

SECTION II.

THREATENED OR COMPLETE FAILURE OF RESPIRATION OCCURRING INDEPENDENTLY OF ANY MECHANICAL OBSTRUCTION.

Before discussing the management and treatment of this form of respiratory failure it is desirable to briefly summarise what has already been said as to its causation.

General Summary.—Threatened or complete failure of breathing of a non-obstructive character may occur under all anæsthetics. We have seen that it may arise in the following ways :—

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[1] See *Brit. Med. Journ.*, vol. i. 1872, p. 419.

[2] See *Med. and Surg. Reporter*, 1867, and also Agnew's *Prin. and Prac. of Surgery*, vol. iii. p. 44.

[3] A very interesting and instructive case, in which the broken blade of a pair of extraction forceps entered the larynx, is reported by Sir William MacCormac (see *Lancet*, Jan. 2, 1886). The patient was lying in the semi-recumbent posture on a couch with the head raised by pillows. Chloroform was given. The broken blade entered the larynx during two or three deep inspirations. A violent fit of spasmodic coughing immediately took place. The patient became livid and much distressed. Subsequently dyspnœa, cough, and pain were complained of, and Sir William MacCormac, by a most skilfully planned operation, removed the foreign body, through a tracheal opening, from the right bronchus.

(1.) **From an Over-dose of the Agent Employed.**—This action of the anæsthetic upon the nervous mechanism of respiration has been already considered in previous pages; and as special descriptions have been given of the symptoms which characterise an over-dose of each agent, it is unnecessary to give any illustrative cases of this variety of respiratory failure.

(2.) **From Intercurrent Asphyxia.**—Cases occasionally occur in which some intercurrent asphyxial condition appears to be the principal if not the sole cause of the failure of breathing.

(3.) **From Morbid States of the Respiratory Mechanism.**—Affections of the lungs, bronchi, pleuræ, chest walls, and abdomen may predispose to, or be the immediate cause of, the suspended breathing.

(4.) **From Syncope.**—Respiration may become arrested in the course of syncope from various causes, the respiratory centre probably failing by reason of anæmia.

(5.) **From Direct Irritation of the Vagus** (?)—A case in which this was the probable cause is given on p. 304.

As already indicated (Part II. Chap. VIII. p. 304), the preliminary administration of **morphine** before an anæsthetic may favour the occurrence of non-obstructive respiratory arrest.

In most cases respiratory failure of this kind comes about more or less gradually. The breathing grows shallower and shallower till it ceases altogether; or the standstill is preceded by irregular jerks and inspiratory catches. In very rare cases the arrest takes place with unexpected suddenness. Speaking clinically, non-obstructive cessation of breathing appears to have, as its immediate cause, a sheer inability of the nervous mechanism to carry on respiratory movements. In such cases artificial respiration will be found easy of application, and, if commenced soon enough, remarkably successful. In other cases, however, a totally different state of things exists, for the cessation of breathing takes place, not from muscular paralysis but from muscular spasm, the chest being rigid and fixed (see p. 160). In these latter cases the greatest difficulty may be experienced in restoring breathing by artificial means.

Shallow and almost imperceptible respiration does not of itself necessarily imply that danger is present. Other signs must be consulted. So long as the normal colour of the face and ears is not materially altered, so long as the pulse is not markedly affected, and so long as the conjunctiva is distinctly sensitive to touch, feebleness of breathing means very little. For example, it is the rule rather than the exception, after the withdrawal of ether or chloroform, for the respiration to become so tranquil that it can hardly be detected; and the same condition may be met with during the too sparing use of these anæsthetics. Deeper and audible breathing is to be secured by more of the agent in use. But should the feeble respiration co-exist with a pallid, dusky, or cyanotic complexion, a small, slow, or irregular pulse, and a totally insensitive conjunctiva, the anæsthetic should be withheld, for these signs collectively indicate that complete cessation of breathing is imminent.

Treatment of Threatened Arrest of Respiration.—When respiration threatens to come to a standstill, without actually ceasing, and the administrator feels certain that there is no mechanical impediment within the air-passages, the following treatment should be adopted. **The anæsthetic should at once be removed, and the lips lightly but briskly rubbed from side to side with a dry cloth, or the chest flicked with a wet towel.** Halting and feeble breathing under chloroform may usually be re-established by lip-rubbing, the immediate effect of which is often very remarkable. I have not infrequently seen respiration, colour, and pulse immediately improve on briskly rubbing the lips, and it is a measure which should never be neglected in minor cases of difficulty. Sometimes breathing can only be kept satisfactorily proceeding by this little manœuvre. Should these measures not succeed, the respiration should be assisted by **pressing, with each feeble expiratory movement, upon the chest walls.** Gentle rhythmic pressure upon the sternum with one hand, or similar pressure upon the sides of the chest with both hands, should be made. In one or other of these ways actual cessation of breathing may often be averted. The subcutaneous injection of **strychnine**,[1] which Dr. H. C. Wood found to produce a markedly stimulant effect upon respiration in the lower animals, is certainly worthy of trial, should circumstances permit, when breathing thus gradually tends to come to a standstill. From 3–5 min. of the Liq. Strychninæ Hydrochloratis might be given subcutaneously, and soon repeated if necessary. The following case illustrates the beneficial effects of chest compression in suspended breathing, probably due to interference with the vagus.

Illustrative Case, No. 32.—The patient was a well-nourished, florid man of 60, with epithelioma of the tongue, palate, and floor of mouth. He had had some whisky and water ten minutes before the administration. I placed him well under ether, and then went on with chloroform. Preliminary laryngotomy was performed, and Trendelenburg's tampon introduced. During the exposure of the carotid artery in the neck for the purpose of placing a temporary ligature round it, the respiration rather abruptly ceased. There was no obstruction. The pulse was little if at all affected. Respiration returned after two or three compressions of the chest. It again ceased, however, two minutes later; but again re-appeared when the chest was compressed as before. No further trouble was experienced during the removal of the tongue and growth.

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[1] Dr. H. C. Wood has kindly sent me a pamphlet entitled 'Strychnine as a Respiratory Stimulant,' which gives his experiments with this drug. In one case of opium poisoning, seven injections, each of $\frac{1}{16}$th gr. of sulphate of strychnine (= about 6 min. of Liq. Strychninæ Hydrochloratis) were given.

The above case is of interest when read in association with Illustrative Cases, Nos. 38 and 39, pp. 318 and 319. Irritation of the vagus was the only cause which could be suggested for the respiratory failure. The patient's circulation was at the time stimulated not only by alcohol but by ether; and respiration rather than circulation became impaired during an operation in the neighbourhood of the vagus. In Illustrative Cases, Nos. 38 and 39, the patients had not been given alcohol, nor had they had ether before chloroform, and circulation rather than respiration became enfeebled during manipulations in the region of the vagus.

Treatment of Complete Arrest of Respiration.—Should the respiration actually cease—and this will be known by the absence of all thoracic and abdominal movements, the increasing duskiness of the face, and inability to feel or hear the passage of air from the mouth or nose—systematic **artificial respiration** should be resorted to without a moment's delay.

Silvester's Method of Artificial Respiration.[1]—If the patient be lying lengthwise upon a bed, he should be rapidly placed transversely, and his head allowed to hang over the side. Should he be lying upon an operating-table, similar extension of the head should be effected over the end of the table. If he be in the sitting posture at the time of the respiratory failure, he should be at once placed on the ground with his shoulders slightly raised and his head extended. Although it is here assumed that no mechanical impediment to breathing exists, it is best, as a routine practice, to apply the tongue forceps, and to make traction upon this organ in order to be quite sure that it is not obstructing breathing. As is well known, the respiration may become obstructed so inaudibly that an error in the diagnosis of the kind of respiratory failure may easily be committed. Full extension of the head and neck, as pointed out by Dr. Howard,[2] tends to

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[1] See 'The Discovery of the Physiological Method of Inducing Respiration in Cases of Apparent Death from Drowning, Chloroform, Still-birth, Noxious Gases, &c.,' by Henry R. Silvester, 1863.

[2] See *Lancet*, Oct. 27, 1888, and *Brit. Med. Journ.*, Nov. 7, 1888, 'On Raising the Epiglottis.'

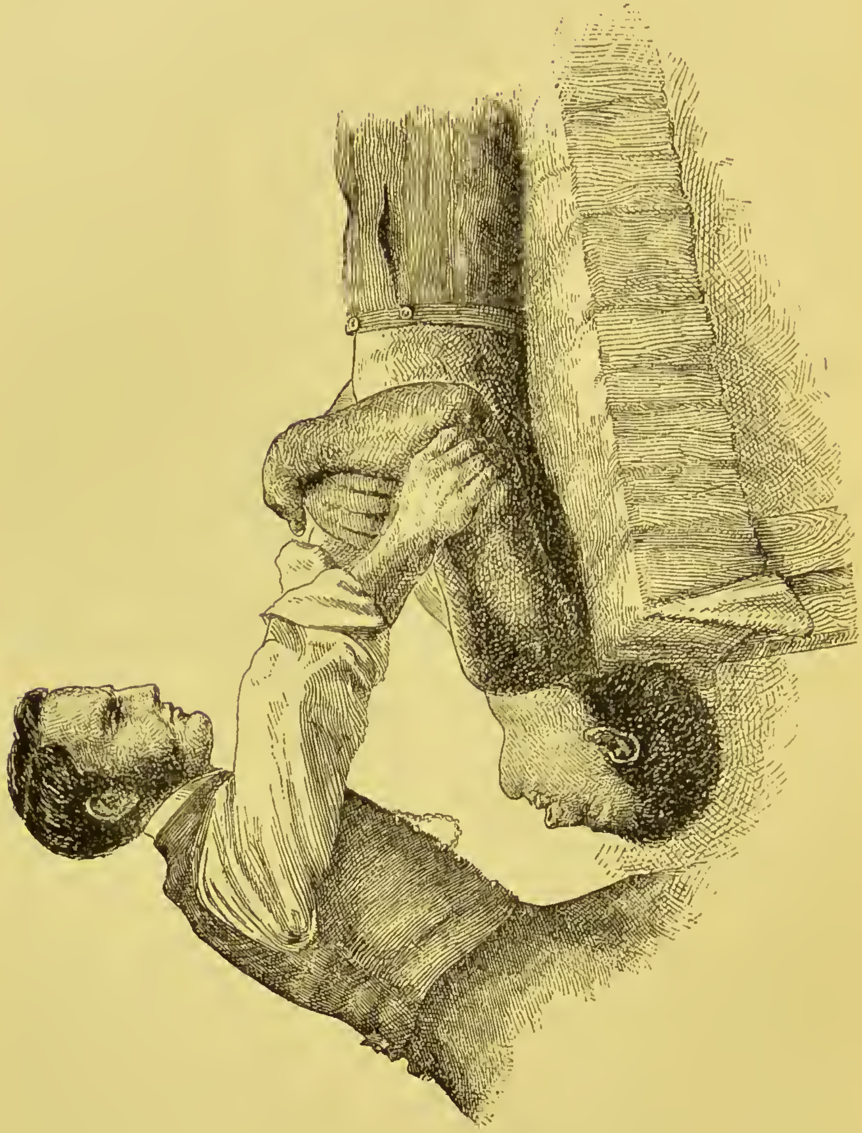

Fig. 55.—Artificial Respiration by Silvester's Method (Expiration). From a photograph.

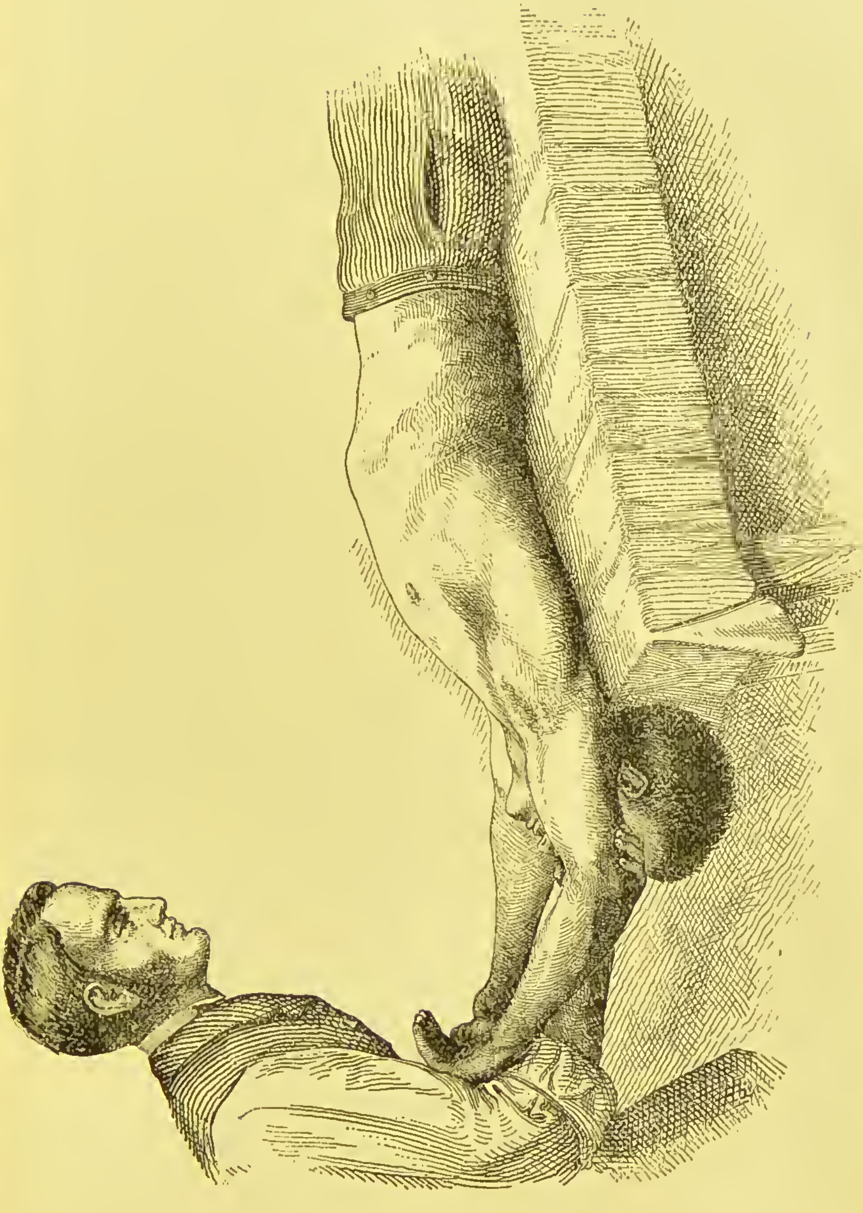

Fig. 56.—Artificial Respiration by Silvester's Method (Inspiration). From a photograph.

keep open a free air-way. The administrator should stand behind his patient, and, grasping the arms at the elbows, should press them firmly and steadily against the sides of the chest (Fig. 55). In the vast majority of cases this pressure will cause an expiration; but should it not do so at once, forcible pressure below the costal margins, and directly towards the diaphragm, should be brought to bear. After the arms have been steadily pressed against the sides for about a couple of seconds, they should be brought deliberately towards the administrator, so that they come into the long axis of the patient's body, on either side of his head. This procedure usually has the effect of enlarging the capacity of the chest by causing the pectoral muscles to raise the upper ribs. In this way (Fig. 56) inspiration is effected. The arms should be kept extended for about a couple of seconds, after which they should be again brought to the side as in Fig. 55. These expiratory and inspiratory movements should be repeated regularly and steadily about fifteen times per minute, careful watch being kept for any spontaneous respiration. If any signs of the latter appear, the natural movements should be supplemented by the artificial, till the breathing has become thoroughly re-established. Care must be taken throughout to maintain a free air-way, and not to exert undue and unnecessary force during expiration. Ribs have been fractured; and rupture of the liver has actually occurred from too roughly handling the patient.

In *Pacini's* modification[1] of Silvester's method, the operator, having his abdomen against the head of the patient, places his hands in the dorsal folds of the axillæ, and pulls the shoulders towards him with an upward movement. The shoulders are then relaxed, and the former movement is repeated.

There are other methods of performing artificial respiration; but, putting aside those in which the chest is inflated by means of bellows, they are all inferior to Silvester's, in that they do not provide for any inspiratory action beyond that resulting from the elastic recoil which follows chest compression.

Chest Compression.—Rhythmic compression of the chest walls, each compression being followed by a removal of the pressure, has already been alluded to as of service in threatened respiratory arrest. As Sir B. Richardson points out,[2] this plan is particularly useful in young subjects, *i.e.*, those with elastic thoracic parietes.

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[1] Introduced into England by Dr. Bain. See *Lo Sperimentale*, T. xxxvii. 1876, p. 39; *Lancet*, Dec. 19, 1868, p. 799; *Trans. Roy. Med. Chi. Soc.*, 1870, vol. 53, p. 291.

[2] 'Artificial Respiration: The Theory and the Practice' (*Asclepiad*, 1890, p. 201).

Indeed, in the treatment of suspended breathing in children, this simple chest compression usually answers as well as any other method of resuscitation.

Marshall Hall's Method.—In Marshall Hall's, or the postural method, the weight of the patient's trunk is utilised to effect thoracic compression, *i.e.*, expiration. The patient is placed face downwards, his chest being supported by a pillow or folded article of clothing, and he is then gently rolled on to his side. These procedures are repeated about fifteen times a minute. Whilst the patient is lying in the prone position expiration is assisted by making pressure upon the back.

Howard's Method.—For the performance of artificial respiration by Howard's method,[1] the patient must be so placed that his shoulders are somewhat raised, and his head and neck fully extended. His hands should be loosely tied together and thrown over his head. The administrator, who must kneel astride his patient, should spread open his hands so that his thumbs and little fingers rest upon the inner margins of the free borders of the costal cartilages, the tips of the thumbs being placed over the ziphoid cartilage. Forcible and sudden pressure is brought to bear upwards and inwards towards the diaphragm for two or three seconds. The pressure is then suddenly removed, the administrator resting for three seconds before repeating the procedure. Seven to ten compressions should be made per minute.

Direct Inflation.—Direct inflation of the lungs, by means of bellows, was the recognised method of performing artificial respiration before the plans above described were known to the profession. Amongst those who have invented and used specially constructed bellows for lung-inflation may be mentioned John Hunter,[2] Sibson,[3] Plouviez,[4] Marcet,[5] Richardson, and Fell.[6] When the simpler and handier methods of Marshall Hall and Silvester began to find favour, direct inflation of the lungs fell into disuse; and at the present time it is rarely if ever employed. As already indicated, however (p. 160), cases occasionally occur in which the chest is found to be so rigidly fixed that the measures which have been discussed in the preceding paragraphs, even though skilfully applied, completely fail to effect an entry and exit of air; and it is in such cases as these that what has been termed 'forced artificial respiration' probably holds out the best chances of success. But we must not speak too positively as to the treatment of a condition the nature of which has yet to be fully investigated. A rigid state of the chest is more particularly prone to occur in patients with emphysema and other chest affections, and there can be no doubt that when such a state does arise the patient is placed in imminent danger. It is hence a matter of the greatest importance that recognised lines of treatment for such a condition should be worked out, and it is to be hoped that further attention will be paid to the matter. Respiratory failure occurring in a patient with a yielding and resilient chest is comparatively easy to treat. But what treatment should be adopted when the chest fails to yield to compression, and to enlarge in response to arm-extension? As before mentioned, I have seen two striking instances of this condition, and one other has been published by Sir Joseph Lister. It is, indeed, probable that the state is more common than is usually imagined, and that some chloroform fatalities have arisen in consequence of the failure of ordinary methods of artificial respiration. Everything seems to point to lung-inflation as an appropriate remedy in the class of cases under consideration. But the question which presents itself is: How may lung-inflation be successfully carried out? From the descriptions which are to be found in articles upon the subject one would gather that, with an ordinary pair of bellows at hand, this procedure is one of extreme simplicity. But this is certainly not the case, at all events when applied to patients whose breathing has ceased during anæsthesia. In the first place, it does not follow, when pumping air by means of bellows into an accurately fitting mask covering the face and nose, or into one nostril whilst the other nostril and the mouth are kept closed, that the lungs will be inflated; for the air-way is very likely to be mechanically obstructed at the time, and one of the chief causes of obstruction, viz., the tongue, cannot for obvious reasons be kept out of the way. In the next place, even supposing that we recognise this difficulty, and pass a tube directly into the larynx, which in itself is not always an easy matter, we may not be able to thoroughly distend the lungs owing to leakage by the side of the tube.[1] The fact is that 'forced artificial respiration,' although easy enough of application[2] in the physiological laboratory, or upon the cadaver, is not devoid of difficulty when applied by the nose or mouth to the patient whose breathing has become arrested during anæsthesia. Dr. H. C. Wood[1] has lately discussed the question, though not specially in connection with fixity of the chest, for which it would seem to be more particularly suited. He advises that a pair of ordinary bellows should be used, and that they should be connected to a face-piece by means of tubing. If the mask prove inefficient, he advises that an intubation tube (two sizes of which ought to be kept in readiness) should be employed.

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[1] See *Lancet*, Aug. 11, 1877; *Lancet*, May 25, 1878, p. 748; *Lancet*, Nov. 1, 1879, p. 659.

[2] *Asclepiad*, 1890, p. 201, *et seq.*

[3] Silvester, *op. cit.*

[4] Kappeler, *op. cit.*

[5] *Proc. Roy. Med. Chir. Soc.*, vol. iv., 1861–64, p. 45.

[6] *Brit. Med. Journ.*, March 1, 1890, p. 495; *Brit. Med. Journ.*, Aug. 16, 1890, p. 384.

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[1] Marcet, *op. cit.*

[2] Bickersteth is stated by Kappeler to have used bellows attached to a tracheotomy tube, and Dr. George E. Fell has in later years also adopted this method of lung-inflation.

Immediate Insufflation.—Immediate insufflation is inferior to other methods of artificial respiration, in that expired and not common air is introduced into the lungs. It has, nevertheless, proved of use in restoring the respiration of infants and young children, and certainly possesses the advantage that the force exerted by the operator cannot be dangerously great, and is easily controlled.

The Administration of Oxygen.—This appears at first sight to be strongly indicated. But Lallemand, Richardson, Perrin, and Duroy[2] have found by experiment that common air answers just as well. The first-named observer, indeed, states that common air is actually preferable. But even if a more extensive trial of oxygen should prove that this gas is preferable to air, the difficulties in the way of keeping it in readiness must always prevent its use save in hospital practice. Dr. Foy[3] speaks strongly in its favour.

Faradism.—Electric stimulation of the phrenic nerves was originally suggested by Duchenne in 1855 as a means of restoring respiration. He found that by the application of the induced current to these nerves he could produce powerful diaphragmatic contraction in the lower animals; and that a similar result could be obtained in the human subject some considerable time after death. He ascertained, moreover, that in animals poisoned by chloroform, the electrical excitability of the phrenic nerves remained almost or wholly unaltered.[4] Duchenne advised that each electrode of an induction apparatus should be placed over the lower end of the scalenus anticus muscle, on the outer edge of the sterno-mastoid. The latter muscle should be drawn somewhat inwards. The electrodes having been placed in position, the current was turned on for about a couple of seconds, when the diaphragm was found to contract and an audible inspiration to result. Expiration was assisted by compressing the lower part of the thorax and the abdomen for a couple of seconds. The faradisation of the phrenics was then repeated. By employing somewhat larger electrodes than those at first used, Duchenne found that he was able to call into action other muscles capable of assisting inspiration, such as the sterno-mastoid, trapezius, levator anguli scapulæ, the pectorales, the serratus magnus, and the rhomboidei. Faradisation of the phrenics was used successfully by Ziemssen[1] in 1856, in a case of asphyxia; and the same author has recorded a similarly happy result in a case of chloroform poisoning. In the latter case the current seems to have been applied directly to the diaphragm. Snow[2] relates a case in which a 'galvanic apparatus,' which happened to be in readiness, proved very successful in effecting inspiration in a patient who had ceased to breathe during chloroform narcosis; and in this case also the electrodes were applied to the diaphragmatic region and not to the phrenic nerves.[3] In the fatal cases collected by Snow mention is made of 'galvanism' on several occasions. The effects, however, do not appear to have been very marked. When readier methods of artificial respiration became known, faradism gradually commenced to fall into disuse. At the present time it is rarely if ever employed, principally for the reason just mentioned, but partly also because of the difficulties in the way of always having at hand an induction apparatus in working order. It is questionable, however, whether faradism should be completely discarded. When an entry and exit of air can be brought about by Silvester's method, any attempt to carry on artificial respiration by electrical stimulation either of the phrenic nerves or of the diaphragm itself must be regarded as out of place. But should the chest be rigidly fixed, so that all manual methods of artificial respiration prove fruitless, and should an induction apparatus be at hand, faradism of the phrenic nerves should certainly be tried. We have yet to learn whether this immobility of the chest walls—one of the most alarming complications of anæsthesia, and one to which reference has already been frequently made—is the result of spasm of the expiratory muscles. If future observation should lead to this conclusion, faradism may yet be destined to save many lives.

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[1] *Brit. Med. Journ.*, Aug. 16, 1890, p. 384.

[2] Kappeler, *op. cit.*

[3] *Brit. Med. Journ.*, Jan. 23, 1892.

[4] See *De l'électrisation localisée*, by Duchenne, 1872.

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[1] See Kappeler, *op. cit.*, p. 131.

[2] *Op. cit.* The current employed was probably an interrupted (faradic) one.

[3] Dr. H. Lewis Jones, who is in charge of the Electrical Department at St. Bartholomew's Hospital, has kindly compared for me the effects produced by faradisation of the phrenics and faradisation in the region of the diaphragm. He finds by experimenting upon himself and upon me that the application of the electrodes over the phrenics, as suggested by Duchenne, produces very distinct diaphragmatic contraction with immediate entry of air to the lungs; whilst the application of the current to the diaphragmatic region produces violent expiratory efforts apparently from the contraction of the intercostal and abdominal muscles. The application of the current to the phrenic nerves in the neck is not always an easy matter; but when once the nerves have been found (and it is easy to tell when this has been accomplished by the effects produced), the inspiratory action of the diaphragm is very striking.

Prognosis.—With regard to the prognosis in the case of non-obstructive respiratory failure, we may say that, if a pulse can be detected at the wrist when respiration ceases, and air can be made to enter and leave the chest, recovery may almost certainly be looked for. But even though the pulse cannot be felt, the administrator should by no means despair, but should promptly commence, and perseveringly continue artificial respiration. It is almost unnecessary to say that artificial respiration should be kept up so long as there is the slightest chance of restoring the patient. Recovery has been known to take place some considerable time after all signs of natural respiration and circulation have been in abeyance.[1] The most formidable cases are those in which respiration and circulation almost simultaneously cease (p. 218), and those in which the chest walls become so rigidly fixed that artificial respiration by the usual methods is impossible.

During the performance of artificial respiration the patient should be kept as warm as possible, and, if practicable, near an open fire. All other restorative measures should be withheld till respiration has become re-established, unless they can be undertaken by totally independent assistants. To relax the artificial movements for the administration of nitrite of amyl, brandy, &c., would be distinctly wrong. Should ample assistance be at hand, a subcutaneous injection of strychnine and digitalis (m.iij. of the Liq. Strychninæ Hydrochlor., and m.v. of the Tinct. Digitalis) may be given. But the all-important measure of resuscitation is artificial respiration, which of itself is a cardiac stimulant of the highest order.

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[1] I have myself known automatic breathing to return after four hours' artificial respiration. (See Illust. Case, No. 25, p. 273.) In the *Edin. Med. Journ.*, Nov. 1874, a case of chloroform poisoning is recorded in which recovery followed after two and a half hours of artificial respiration. In these protracted cases evidences of cardiac activity were to be detected although natural respiration was in abeyance.

CHAPTER III.

THE MANAGEMENT AND TREATMENT OF THE DIFFICULTIES, ACCIDENTS, AND DANGERS CONNECTED WITH CIRCULATION.

General Summary.—The circumstances under which the heart's action may become enfeebled, or show signs of failure during anæsthesia, have been referred to on several occasions in the previous pages of this work; but it may be well to briefly recapitulate them here, in order that we may be in a position to discuss the treatment which should be adopted.

We may, I think, speak of (*a.*) predisposing, and (*b.*) exciting causes of cardiac depression and failure.

(*a.*) *Predisposing Causes of Cardiac Depression and Failure.*—Amongst these may be mentioned :—

(1.) Extreme exhaustion or shock consequent upon disease or accident.

(2.) Valvular and other cardiac affections attended by an embarrassed or feeble cardiac action.

(3.) Profound mental disturbances.

(4.) Advanced arterial degeneration.

(1. and 2.) **Extreme Exhaustion or Shock. Cardiac Affections attended by Feeble or Embarrassed Cardiac Action.**—With regard to these causes we may here repeat what has already been said, viz., that although patients with embarrassed and feeble cardiac action take anæsthetics, as a general rule, remarkably well, they are nevertheless not in such a favourable condition to withstand any prolonged or severe strain upon the heart as patients with a healthier circulation (see p. 25).

(3.) **Profound Mental Disturbance.**—The effects of fear and profound mental disturbance upon the circulation have been discussed on p. 224.

(4.) **Advanced Arterial Degeneration.**—It is necessary to refer to this condition here, as it is conceivable that, by leading to cerebral hæmorrhage, it might thus bring about circulatory depression during anæsthesia. Such a contingency, however, is so extremely remote that it may be disregarded.

(*b.*) *Exciting Causes of Cardiac Depression and Failure.*—Of these we may mention :—

(1.) The surgical procedure for which the anæsthetic is given (p. 32).

(2.) Any pronounced asphyxial condition occurring during the inhalation (p. 226).

(3.) The administration of toxic doses of the anæsthetic.

(4.) The act of vomiting.

(1.) **The Surgical Procedure.**—Of operations most likely to induce circulatory feebleness or failure may be mentioned :—Those in which very severe hæmorrhage occurs (*e.g.*, the removal of a large sarcomatous growth from the upper jaw); those in the neighbourhood of the solar plexus or vagus (*e.g.*, nephrectomy); and the removal of an important organ or member (*e.g.*, amputation at the hip joint). Distinct signs of heart depression are also reported to have arisen during paracentesis thoracis (from the sudden alteration in the heart's position), and during the evacuation of fluid from the abdominal cavity. The possibility of syncope taking place from the entry of air into veins during operations has been sufficiently considered (p. 227).

The two following cases illustrate the effects of very profuse hæmorrhage upon the circulation of the anæsthetised patient. In Case 33 the patient was at the time of operation considerably depressed by purgation, and this may have had some influence in the causation of the symptoms. In Case 34 the patient was a thin, feeble woman, and unable to bear loss of blood without quickly showing signs of exhaustion. By anticipating shock, it was possible to tide her over a somewhat formidable operation. Towards the close of the operation I was able to maintain an analgesic rather than a truly anæsthetic state.

Illustrative Case, No. 33.—F., æt. 60. Rather stout; not very strong. Fair chest expansion. Heart sounds rather distant. No winter cough. Had one ounce of castor-oil the night before operation. Three actions of bowels. Operation 8.30 A.M. for removal of left upper jaw for sarcomatous growth. Gas and ether given. Deep ether anæsthesia soon came on. Operation commenced after five minutes of ether anæsthesia (see p. 35). The gas and ether had been given by Mr. Braine's method (see p. 180). Head on side, with right cheek on pillow, and face turned towards floor. Operation begun. No embarrassment to breathing from blood, as all drained into, and then out of, right cheek. As effects of ether passed off, anæsthesia kept up by chloroform from a Skinner's mask. Very profuse hæmorrhage. Less anæsthetic given. Respiration quite regular. Pulse not observed. Head always kept low. Conjunctival reflex just present. As the hæmorrhage continued to be free I attempted to feel pulse, but could not detect one at either wrist. Hands quite warm. Respiration proceeding regularly.

Lion forceps now applied and jaw removed. Very little hæmorrhage, probably from feeble circulation. Sutures rapidly inserted, and operation finished. Respiration still regular, but occasionally feeble. Still no pulse. Half an ounce of brandy, with some water, given per rectum; a subcutaneous injection of ether administered, and ammonia applied to nostrils. No effect produced. Respiration could be kept proceeding satisfactorily so long as the lips were occasionally briskly rubbed with a towel (see p. 230). Lips pale, but pinkish. Ears and cheeks pale. The wrist pulse remained absent for twenty or twenty-five minutes, and then gradually returned. Head kept low. Hot cloths applied to head. Even when the patient became half-conscious, the wrist pulse was barely perceptible. The patient made an excellent recovery.

Illustrative Case, No. 34.—F., æt. 40. Short stature and thin. Large cystic sarcoma of left breast. The tumour rendered a stethoscopic examination of heart almost impossible. Operation for removal of growth. Ether given by means of Clover's portable inhaler. Pulse during first part of operation very fair. Tumour very vascular: hæmorrhage free. Pulse gradually grew weaker and quicker. The first indications of shock were:—(1) quickened pulse: (2) dilatation of pupil: and (3) some pallor. Although the patient was well under the anæsthetic when incisions made and removal of breast begun, she was allowed to regain lid-reflex when the hæmorrhage became free. For the last 20 minutes of operation she was more or less conscious, with widely dilated pupils, good conjunctival reflex, weak and rapid pulse (about 130), and considerable pallor. A breath of ether with plenty of air given occasionally. Respiration quiet, shallow, and regular. Whilst sutures were being put in she was able to answer questions, though feebly and slowly. The operation lasted one hour. It may be added that any attempt to keep up a deeper anæsthesia than that described was at once followed by greater rapidity of pulse and loss of tone in the eyelids, so that a moderately deep anæsthesia was maintained after the skin incisions had been made and the removal of the tumour begun.

That the surgical procedure may, independently of the occurrence of hæmorrhage, very seriously and sometimes very suddenly depress the circulation of the patient, will be seen by referring to the following cases. In the first three of these, viz., Cases 35, 36, and 37, ether was being employed; and in the remaining four, viz., Cases 38, 39, 40, and 41, chloroform.

Illustrative Case, No. 35.—F., æt. about 35. Very anæmic from long-standing hæmaturia. Short stature and spare build. Pulse 84, regular and extremely compressible. No respiratory difficulty. Nephrectomy for renal tumour. Time 10.40 A.M. Administration commenced with A. C. E. mixture on Skinner's mask. At 10.42 respiration rather rapid—suggestive of hysteria. 10.43 Ormsby's inhaler, charged with ether, gradually applied. Deep anæsthesia rapidly produced. Pulse fair, but quicker than before commencement. Patient lying on side with pillow under loins: head low: face towards bed. Respiration regular and not hampered. 10.52 operation begun. No reflex movement. At 11, whilst pedicle was being tied, distinct evidences of shock began to manifest themselves. Pulse rapid and feeble. Allowed patient to regain conjunctival reflex to a slight extent. Respiration regular and snoring. Pulse soon became barely perceptible at wrist. Hands warm. Fair colour. Respiration less deep and non-stertorous. As pulse now almost imperceptible operation rapidly completed. Whilst the patient was in this condition the breathing was suddenly 'held,' as if straining or coughing were imminent: but as the suspended respiration persisted, the sternum was pressed five or six times, and air was heard to enter and leave the chest. Automatic breathing then returned and continued, though with occasional pauses. End of table raised. Operation completed. Patient's condition gradually improved. Fifteen minutes after operation, the pulse could be counted at wrist. Patient moved to bed and kept very warm. No vomiting. Made a good recovery.

Nephrectomy in a feeble and very anæmic patient is prone to be attended by shock, and, as the above case shows, the resources of the administrator of the anæsthetic may be severely taxed. That the symptoms were not due to loss of blood is perfectly certain, seeing that every care was taken, and with the most perfect success, to avoid unnecessary hæmorrhage. Nor was the anæsthetic to blame, seeing that the symptoms of the patient in no way corresponded with those dependent upon an over-dose of ether.

Illustrative Case, No. 36.—F., æt. 70. Active. Stout. Good regular heart sounds. No evidence of bronchitis. No breathlessness. Amputation of left breast. 9.30 A.M. No food or drink since last night. Administration conducted as described on p. 256. A. C. E. mixture given on Skinner's mask. No resistance or difficulty. Changed to Rendle's mask in a minute or two. Breathing rather quick. Then changed to Ormsby's inhaler charged with pure ether. No difficulty beyond transient 'holding of breath.' No struggling. Soon stertorous, but with slight conjunctival reflex. As the breathing was rather jerky (from large abdomen) and the lips flapped audibly with expiration, somewhat less ether was given. Breathing less jerky. Two very long skin incisions made. No movement or reflex noise, but a slight hesitation in breathing noticed, *i.e.*, a slight straining with expiration. As the anæsthetic was continued this quickly passed off and breathing became regular. Although colour and respiration good, no pulse could be detected either in radial or temporal artery. The colour was perhaps a trifle paler than normal, but nothing more. Pupils moderately contracted. Very slight lid-reflex. Ether suspended for a while. Still no pulse: but respiration proceeding. After pulse had thus been absent for about ten minutes, it returned, and with it brisk lid-reflex and some expiratory phonation. For rest of operation pulse good and regular, and colour very good. Administration lasted one hour. 4½ oz. of Robbins's ether used. Some retching after.

The above case is, in my experience, unique. It is extremely interesting as showing that reflex circulatory depression may arise even under the stimulant effects of ether. As already mentioned

(p. 33), cessation of the wrist pulse at the very moment the operation was commenced has been repeatedly recorded under chloroform. But it is certainly extremely rare under ether. It is possible that at the moment the long skin incisions were made the patient was too lightly under the anæsthetic, but this is quite doubtful. It is said by some that operations upon the *left* breast are particularly prone to be attended by temporary disappearance of the pulse and other circulatory effects.

Illustrative Case, No. 37.—M., æt. about 18. Thin: breathless on slight exertion: has some dulness at bases of lungs. Syme's amputation for sarcoma of foot. Commenced administration with a small quantity of the A. C. E. mixture on Skinner's mask. Then went on with pure ether from a Clover's portable inhaler. He breathed the ether well at first: but soon commenced to give some trouble. The upper lids became raised, and it was difficult to secure tranquil anæsthesia. The lid-reflex persisted, and also some muscular movements, for about ten minutes. Breathing somewhat hampered. Whilst he was in this condition the operation was commenced. It so happened that I had my finger upon the radial pulse, and that the student who was administering the ether under my supervision had his finger upon the carotid artery. The pulse was good but quick. At the moment the skin incision was made, the pulse suddenly ceased both at the wrist and at the neck, and remained absent for (?) four or five seconds. No loss of colour. Pulse resumed its previous character. Some movement of patient, showing he was not deeply anæsthetised. Attempted to secure a better and more profound anæsthesia, but respiration tended to become feeble and face pale. No further trouble during rest of operation. This patient died some weeks later, and at the autopsy a large mediastinal (sarcomatous) tumour was discovered. This had probably caused the respiratory difficulties in the administration.

It must be admitted that in the above case the patient was, at the moment of incision, imperfectly anæsthetised. The operator understood that the patient was ready for operation; whereas, owing to the embarrassed respiration, it had been found impracticable to arrive at tranquil anæsthesia in the usual time. It is probable that had the patient been under chloroform a more serious depression of circulation would have resulted.

Illustrative Case, No. 38.—The patient was a gentleman of about thirty-five years of age; of average build; in good general health; and not markedly nervous. He was the subject of a sarcomatous tumour of the soft palate. Chloroform was administered by means of Junker's inhaler. Anæsthesia was produced in from 8–10 minutes, and was characterised by muscular flaccidity, abolition of lid-reflex, and slight stertor. There were to be two stages in the operation—the first of which consisted in placing a temporary ligature round the carotid artery in the neck; the second in removing the growth of the palate. The skin incision was unattended by movement or other phenomena.

Whilst the artery was being exposed, the pulse became extremely feeble, the face pale, the respiration shallow, and the operator had some difficulty in recognising the vessel by reason of its diminution in size. The head was lowered and the legs raised. After three or four compressions of the chest the pulse gradually improved, and rigidity and lid-reflex re-appeared. I then had recourse to ether for the remainder of the operation, which was successfully performed under this anæsthetic.

The next day, whilst the wound over the carotid was being examined without an anæsthetic, the patient's face suddenly became pale, the artery contracted as on the previous occasion, the eyes turned up, the muscles of the jaw twitched, and for a few seconds the patient was unconscious.

I anæsthetised this patient two years later, and gave him ether for the removal of a very small recurrent nodule. No difficulty occurred. It is fair, however, to add that no ligature was this time placed round the carotid.

Illustrative Case, No. 39.—M., æt. 60. Healthy and muscular. Florid cheeks. Iron grey beard. Had his tongue removed some months ago. Now has epitheliomatous glands of neck requiring removal. Heart sounds good; not nervous. Chloroform administered on Skinner's mask. Drop bottle. No struggling. Some temporary respiratory difficulty before deeply under, easily relieved by pushing jaw well forwards. Fully anæsthetised in 5–6 min. No movement with skin incision. The signs of anæsthesia were :—Regular, softly snoring breathing : no corneal reflex : fixed eye-balls : pupils ● ($= 3\frac{1}{2}$ mm.) : good colour. As this pupil was a trifle larger than the ordinary chloroform pupil, I instructed the student who was administering the chloroform to somewhat lessen the amount of anæsthetic. This brought the pupil to ● ($= 2\frac{1}{2}$ mm.) in about half a minute. Other signs as before. A few minutes later, during the manipulations of the surgeon for the removal of the glands (which were intimately connected with the carotid, jugular, vagus, and phrenic), the patient became pale, and his jaw muscles flaccid. In a few seconds from this his breathing became irregular and shallow. No sound of obstruction. I assisted respiration by pressing with each expiratory effort upon the lower part of thorax, and with my finger in mouth kept stump of tongue from pharynx. The pulse, which had not been observed before, was barely perceptible and slow. (It had probably ceased altogether when the pallor came on.) Lid-reflex now returned, and some moaning. Carotid and jugular both ligatured and glands completely and successfully removed. The operation was never suspended, as no further remedy besides chest-compression was necessary. A comparatively light anæsthesia was kept up for the rest of operation. Any attempt to abolish lid-reflex was at once followed by feeble breathing. The colour and pulse improved after the chest-compression; but patient remained pale, and with rather slow and weak but regular pulse till end of operation. Administration lasted 50 min. 14 dr. of chloroform used.

I venture to regard the two preceding cases as of great practical importance. They so strikingly resemble one another that we must, I think, admit that the symptoms were due to vagus irritation. The syncope came on whilst the vagus was being pulled upon. *In each case the patient was deeply under the anæsthetic.* In fact, the only alternative supposition is that the anæsthetic was the cause of the symptoms. But from the rapidity with which the patients regained muscular tonus; from the behaviour of the pupil; from the fact that pallor preceded respiratory arrest; and from the symptoms having come on at the moment when the vagus was being interfered with; there is little room for doubt in the matter. Had one not been observing the patient very closely, a mistake in the diagnosis would probably have been committed.

Illustrative Case, No. 40.—F., æt. 32; thin; tall; very fair; light chestnut hair; good heart sounds and chest expansion; nervous, but nervousness under control. Commenced with gas and ether. Some opisthotonus and holding of breath during transition from gas to ether, but no difficulty; and patient soon breathed regularly and stertorously. After four to five minutes of satisfactory and deep etherisation, during which corneal reflex was absent, the colour good, the respiration regular and deep, and the pupils of medium size or rather large, I changed to chloroform in obedience to the wishes of the operator. Chloroform given on Skinner's mask. Stertor not allowed to subside, *i.e.*, deep anæsthesia was maintained. Corneal reflex, however, reappeared to a slight extent; and pupils became ● (3 mm.). Good colour. Pulse not observed. A small tentative incision (to discover nature of tumour) now made. This made pupils ● (4½ mm.); but no other reflex effect observed. No movement. Respiration still deep and good. Pulse now felt for first time and found to be markedly irregular. Less chloroform given. Pulse became regular; corneal reflex a trifle more distinct; pupils ● to ● (2 to 2½ mm.); respiration good. The fact that the pulse was irregular with *more* and regular with *less* chloroform, led me to conclude that the deeper anæsthesia was in this case unadvisable. A long incision was now made to remove the breast, and the regular pulse at once became almost imperceptible at the wrist, but re-appeared in a few seconds, and was then remarkably slow (? about 40) and occasionally irregular. No movement during incision. With this slow pulse pupils about ● (2½ mm.). The colour was fairly good, but possibly a trifle less florid. Respiration unaltered. I now changed to ether, under which the pulse at once grew quicker (about 90) and perfectly regular. No further trouble.

In this case two facts are apparent:—(1.) That a very deep chloroform anæsthesia was attended by such an alteration in circulation as to render this very profound narcosis unadvisable; and (2) that an anæsthesia somewhat less profound was attended by well-marked cardiac inhibition at the moment a large incision was made. If a very deep anæsthesia is not liable to be attended by the phenomena described, we should obviously attempt to secure such a condition; but in this case it was certainly not advisable to proceed so far.

Illustrative Case, No. 41.—Healthy-looking child, about 5 years of age. Nephrectomy for sarcoma of kidney. Chloroform on Skinner's mask administered by a student under my supervision. All went well till fifteen minutes after the commencement of the operation, when, during the manipulations of the surgeon, the following events occurred in the order mentioned:—(1.) The pulse became very slow, the respiration being regular and the colour good. The anæsthetic was withheld. (2.) The pulse became slower and feebler, and the respiration almost imperceptible, whilst the lips remained of good colour. (3.) The radial pulse ceased and the colour became dusky. Inversion and artificial respiration very quickly restored the circulation.

The above case is a good illustration of surgical shock occurring even during deep chloroform anæsthesia. Operations upon the kidney are apparently more prone than any others to cause this form of cardiac depression, and such symptoms are more likely to arise, and are of a more urgent character, when chloroform is used than when ether is employed. But that they may manifest themselves under ether is certain, as Illustrative Case, No. 35, p. 316, demonstrates.[1]

(2.) **Intercurrent Asphyxia.**—With regard to asphyxial conditions coming into play during surgical anæsthesia, we have seen: that in whatever way such conditions may originate the result is invariably the same, viz., gradual circulatory depression: that this result is more quickly produced under chloroform than under nitrous oxide or ether: and that it occurs in its worst forms in patients with originally feeble cardiac action. In the following case the temporary withdrawal of oxygen, during the administration of nitrous oxide to a patient with aortic disease, was probably the exciting cause of the temporary cardiac failure.

Illustrative Case, No. 42.—A young man, in domestic service, presented himself at the Dental Hospital with the object of having a tooth extracted under nitrous oxide. As there was nothing in his appearance or behaviour to suggest any serious visceral disease, I administered nitrous oxide gas. The breathing and pulse became feeble. All that was necessary was to compress the chest two or three times, when the colour improved and the breathing returned. On examining the chest stethoscopically double aortic disease was found to exist.

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[1] I have lately been informed by Dr. Amand Routh of an interesting condition which he observed in a patient under chloroform for dilatation of the os uteri. The pulse fell to 24 per min. during the stretching of the internal os. Dr. Routh also tells me that he has on other occasions noticed an intermission in the cardiac beats each time the internal os was stretched by Hégar's dilators. Since this information from Dr. Routh I have watched the pulse during dilation of the cervix. In one case only, that of a florid young lady deeply under ether, have I detected an occasional intermission during the stretching. I have never given chloroform for this operation, so cannot speak of the circulatory effects which may occur.

In Dr. Sheppard's notes I find a case recorded in which, at the moment the soft palate was seized by forceps, prior to an operation upon it, the patient, who was under chloroform, suddenly became pale and the pulse feeble.

(3.) **Direct Effects of Anæsthetic.**—As to the depressing effects of anæsthetics themselves upon the circulation, we have seen that danger from this quarter is not as great as has been hitherto believed. It is true that all anæsthetics eventually act as cardiac depressants, but this action does not as a rule become a distinct feature of the case till respiration has shown signs of failure, or has actually ceased. The rare cases in which, during the administration of nitrous oxide or ether, the heart has shown signs of failure before respiration has become obviously impaired, are probably best explained on other grounds, *e.g.*, asphyxia, surgical shock, vomiting, &c. With chloroform, however, it must be admitted that there is considerable clinical evidence to support the view that this anæsthetic does occasionally exert a primarily depressing influence upon the heart itself (see p. 220).

(4.) **The Act of Vomiting.**—Lastly, the act of vomiting, as already mentioned, may be accompanied by dangerous or even fatal syncope; but such cases are fortunately extremely rare.

In discussing the remedial measures which should be adopted, we may speak of (*a*) the preventive and (*b*) the immediate treatment of circulatory failure.

(*a*.) **The Preventive Treatment of Circulatory Failure.**—This resolves itself into a careful consideration of the condition of the patient, the nature of the operation, the selection of the anæsthetic, and the preparations necessary for the administration (Part I.). In the case of very exhausted subjects, the operation should, if possible, be planned to take place **early in the morning**; as much nutriment should be allowed as is compatible with the avoidance of after-sickness; the advisability of employing an **enema of brandy and water,**[1] **or brandy and beef-tea**, before the administration, should be considered; that method of giving ether in which the **asphyxial factor is reduced to a minimum** (p. 137) should be chosen; the patient should be **well covered with blankets, and kept very warm**; the **head should**

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[1] See Mr. Christopher Heath on Surgical Shock, *Brit. Med. Journ.*, Feb. 2, 1889, p. 234.

be kept as low as circumstances will permit; not more of the anæsthetic than is necessary should be given; and **free respiration** sedulously maintained. In desperate cases the preliminary subcutaneous injection of mv. of the tincture of digitalis may be tried. The use of alcohol by the mouth is not, as a general rule, to be recommended, owing to its increasing the chance of vomiting. In the case of patients with valvular and other cardiac affections, the avoidance of circulatory troubles principally depends upon the employment of an appropriate anæsthetic, and upon the maintenance of unembarrassed breathing. If the patient be pale, and his pulse distinctly feeble from emotional causes, chloroform is probably best avoided. The choice of anæsthetics in markedly atheromatous subjects has been discussed on p. 26.

(*b.*) **The Immediate Treatment of Circulatory Failure.**—In considering the immediate treatment of circulatory failure, it is first of all necessary to bear in mind that free respiration is essential to good circulation. In many cases, indeed, pulse failure during anæsthesia seems to be principally if not wholly dependent upon inadequate breathing; and if, in such cases, respiration be assisted, the pulse will at once improve. There are very few cases of circulatory failure connected with the effects of the anæsthetic in which any other cardiac stimulants than **fresh air and good respiratory action** are needed. Errors have over and over again been committed in administering subcutaneous injections of ether or brandy, and in employing ammonia or nitrate of amyl, when attention should have been directed to the patient's respiration. There are, however, certain cases in which grave symptoms of circulatory failure arise whilst the breathing is proceeding more or less satisfactorily, and under such circumstances special treatment must be adopted.

In minor cases **the anæsthetic should be withheld**; the patient placed or kept, as the case may be, in the **horizontal position, with the head low**; **a free air-way maintained**; and the **lips and cheeks briskly rubbed with a dry towel.** If the symptoms be due to intercurrent asphyxia, or to the depressing influence of chloroform, they will usually soon disappear by employing these simple measures. If they be connected with approaching vomiting, the lip-friction will probably bring matters to a crisis, and the colour and pulse will then return.

If the circulatory depression be due to surgical shock the question will arise, whether or not the **operation should be discontinued.** This point, however, hardly admits of discussion here. When the patient's circulation is gradually getting weaker and weaker, and the operation is not completed, in addition to the above measures, an enema of **hot water**, with or without **brandy**, may be administered, the **lips wiped with a cloth moistened with brandy, cloths wrung out of nearly boiling water applied to the forehead**, and a subcutaneous injection of the tincture of **digitalis** given. The **injection of normal saline solution**[1] **into the veins** is undoubtedly a mode of treatment of the highest value in some of these cases. By adopting one or all of these measures it will often be found practicable to complete a desperate operation. The effects of **alcohol**, either given subcutaneously or by the rectum, have been often questioned. My own experience leads me to say that in pulse failure which is not immediately due to an over-dose of the anæsthetic, brandy is of considerable service in maintaining the circulation. Dr. H. C. Wood has lately shown that, when the lower animals are poisoned with chloroform, the injection of alcohol into the jugular vein produces no effect upon the arterial pressure. But in many of the cases in surgical practice the heart-failure is due to surgical causes, and in such cases as these alcohol is likely to be beneficial.

Some surgeons speak highly of **nitrite of amyl** given in three or four min. doses, but Dr. Wood's experiments with this drug lead him to regard it, at all events in chloroform-syncope, as valueless. The subcutaneous injection of **ether** is, as this authority points out, irrational. When the pulse and breathing are both feeble in chloroform administration, a few drops of ether sprinkled on the mask will often act remarkably well in stimulating both; but to inject ether in patients already under its influence is obviously worse than useless. Some good may, of course, result, as with alcohol, when the patient's circulation is enfeebled from general exhaustion or surgical shock; but a careful distinction between such cases, and those in which too much of the anæsthetic has been given, must be made before injecting either alcohol or ether. The vapour of **ammonia** (the Liq. Ammon. Fort. diluted with an equal bulk of water answers well) is also frequently employed as a cardiac stimulant; but the same remark applies to this as to the other remedies just discussed. The fact is, that if the circulatory depression has been caused by the anæsthetic itself, or by intercurrent asphyxia, drugs should, as a rule, be avoided, and every means adopted for maintaining free respiration in order to encourage elimination. When, however, the patient's condition is traceable to other causes, such as heart enfeeblement from inherent disease, surgical shock, &c., beneficial effects may be expected from the usual cardiac stimulants, viz., ether (if not already present in the system), alcohol, ammonia, and digitalis.

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[1] I am indebted to Mr. Arbuthnot Lane for some interesting and important remarks on the value of saline injections. He has used the method a great many times with uniform success (1) in cases of hæmorrhage; (2) in acute inflammatory conditions—as, for instance, in the case of very acute tubercular disease, with high temperature and extreme exhaustion; (3) in collapse developing during the course of a severe operation; and (4) during the course of operations for intestinal obstruction, when the patient has been much exhausted by prolonged vomiting or want of food. He has found, under the last-named circumstances, that the patient has been much better after a tedious operation than he was before, in spite of the anæsthetic. Mr. Lane has in most of his cases used simple tap water, though he prefers boiled water for the purpose. The saline solution consists of one drachm of common salt to a pint of water.

Should the pulse become imperceptible at the wrist, and the features pale, whilst respiration is continuing, partial or complete **inversion**, as suggested by Nélaton in 1861, may be adopted. Many remarkable cases are on record[1] in which patients have thus been rescued from imminent death during chloroform anæsthesia. The beneficial effects of inversion are probably to be explained by supposing that the right heart thereby receives more blood than can reach it in other positions of the body; but it is possible that the pressure brought to bear upon the feebly acting heart by the abdominal viscera may be an important factor. In some of the recorded cases in which Nélaton's method has proved successful, the pulse at the wrist could be made to come and go as the patient was inverted or placed horizontally. In children, inversion is easily enough applied; but in adults there is necessarily greater difficulty. It is sometimes a good plan, in heavily built subjects, to secure the feet to the end of the table or bed, and to raise that end. In this way other remedial measures, such as the application of hot towels to the cardiac area,[2] artificial respiration, and the injection of saline solution may be adopted. It is very important that inversion should be restricted to the proper cases. It should never be employed unless the signs of heart failure are distinctly marked.

The beneficial effects of **faradism** are questionable. Professor MacWilliam[3] advises rather strong induction shocks, with the skin moistened, one electrode being placed over the heart's apex, and one over the fourth dorsal vertebra. Schafer and Sigmund Meyer, on the other hand, consider faradism to be as likely to inhibit as to stimulate a feebly acting heart.

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[1] See *Deutsche Med. Zeitung*, Feb. 1885; 'Braithwaite's Retrospect,' vol. i. 1876, p. 348; *Edin. Med. Journ.*, vol. ii. 1874, p. 476. Kappeler states (p. 135) that Schuppert saved three patients by inversion.

[2] *Lancet*, vol. i. 1881, p. 1015.

[3] 'Electric Stimulation of the Heart in Man' (*Brit. Med. Journ.*, Feb. 16, 1889).

Acupuncture and **electro-puncture** of the heart are not to be recommended.

If the pulse and respiration should simultaneously cease, or if respiration should show signs of failure immediately or almost immediately after the disappearance of the pulse has been observed, **artificial respiration,** by Silvester's method, should be at once commenced, in preference to all other measures.

PART IV.

THE CONDITION OF THE PATIENT AFTER THE ADMINISTRATION.

We have seen, in considering the after-effects of each anæsthetic, that, when the administration is discontinued and fresh air admitted to the lungs, a kind of retrogression in the patient's symptoms commences. A true retrogression is rarely if ever observed—that is to say, a patient rarely if ever displays, in reverse order, precisely the same symptoms which occurred whilst he was passing under the influence of the anæsthetic. Speaking generally, we may say that, when the anæsthetic is withdrawn from a deeply anæsthetised patient, the first thing usually observed is that the breathing grows quieter, and should stertor have been present, it becomes less pronounced. The next sign of recovery is usually the re-appearance of the lid-reflex. Deglutition movements sometimes occur first. If the patient be left undisturbed, the pupil generally grows smaller; but dilatation may occur, more especially if the patient be disturbed, or the operation be still in progress. Dilatation may also be met with if vomiting take place. The globes now commence to move from their fixed positions. The breathing becomes intermittently obstructed, from the temporary laryngeal closure incidental to swallowing. Expiratory phonation and inspiratory crowing may become audible. Coughing, retching, or actual vomiting may follow.

Recovery from anæsthesia takes place with a degree of rapidity which is roughly proportionate to the previous duration of the narcosis, and to the quantity of the anæsthetic which has been inhaled. Other factors necessarily come into play. Patients with good respiratory action, a brisk circulation, and a free airway, more quickly eliminate the anæsthetic than patients differently circumstanced. One test of a proper anæsthesia having been maintained is that the patient should soon commence to show signs of recovery. Should he remain with an insensitive conjunctiva, and other evidences of deep anæsthesia, for some time after the administration, we may be pretty certain that an unnecessarily large dose of the anæsthetic has been given.

I find it an excellent practice, when circumstances permit, to **turn the patient well upon his side** immediately after a surgical operation, *i.e.*, whilst he is still under the anæsthetic. This is the position which Dr. Bowles[1] so strongly recommends in apoplectic seizures. Stertor at once ceases; the tongue gravitates to the side of the mouth; a free air-way is established; mucus and saliva are not swallowed; coughing is prevented; and should vomiting occur, any vomited matter will readily find an escape without interfering with breathing. If the patient's head be allowed to remain in the mid-line, and more especially if his chin be permitted to rest more or less upon his sternum, breathing cannot take place freely, and recovery will therefore be tardy and unsatisfactory.

If the patient has been in the sitting position, as for a dental operation, he should be bent well forwards in the chair directly the operation is over, in order to facilitate the escape of blood from the mouth.

It is important that **the administrator should stay by his patient** till distinct signs of recovery have manifested themselves. As a general rule he should remain till some semi-voluntary action takes place, till vomiting has occurred, or till moaning sounds are made. Temporarily obstructed breathing is common whilst patients, and more especially certain types of patients, are emerging from anæsthesia. It is hence necessary for the administrator to conduct his patient safely through the stage of retching; to push the jaw forwards; and to clear the mouth if occasion should require.

Pallor and feebleness of pulse after the administration are often connected with vomiting. They may, however, depend upon other causes, *e.g.*, the patient's general condition, the operation, &c. Moreover, we must remember that both ether and chloroform, and more especially the former, act as stimulants to feeble subjects; and that immediately the stimulant is removed the circulation will inevitably flag to a greater or less degree. We must not lose sight of this fact in dealing with very exhausted subjects, and we must carefully watch them after the anæsthesia is at an end. In critical cases care should be taken to keep the head low and the patient very warm. Hot-water bottles and blankets should be applied; free respiration maintained; the lips rubbed with brandy and water; or an enema of brandy and beef-tea given. Hot-water bottles should always be enveloped in blankets; otherwise there will be a risk of inflicting injury to the skin of the still unconscious patient. I have known the subcutaneous injection of the tincture of digitalis to be of marked benefit in a case of severe surgical shock after an operation; but the treatment of this condition hardly comes within the scope of our inquiry.

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[1] 'Stertor and Apoplexy.'

After the use of ether or chloroform for a surgical operation, no **nourishment** should be given by the mouth for about four hours, and if at the expiration of this period the patient should be disinclined for food, another hour or even longer may be allowed to elapse. Some clear soup or broth may then be allowed. Properly made beef-tea, to which a small quantity of a reliable meat extract has been added, will be found to answer well. Soda-water with milk is sometimes preferred to soup or beef-tea. After short administrations some tea or coffee with dry toast may be permitted. Eggs, milk, or bread and butter may induce vomiting, and are best avoided till the following day.

As the prevention and treatment of **nausea, retching, and vomiting** are matters of considerable importance, not only to the patient but to the surgeon, a few remarks, in addition to those which have already been made in previous pages, concerning the causation of these unpleasant sequelæ may not be out of place. Unfortunately our knowledge is very scanty—far scantier than it should be upon such a subject.

In the first place it is hardly necessary to point out that the presence of food, &c., within the stomach during the administration is the most frequent cause of after-sickness. When the diet has been properly regulated, in accordance with the rules laid down on p. 74, after-vomiting is exceptional. When solids or liquids are present in the stomach during the administration, not only may the administrator have difficulty in obtaining a proper and quiet anæsthesia, but after-sickness will probably be troublesome. As a curious and interesting fact, however, I may say that I have met with one or two cases in which vomiting after ether was conspicuously absent, even though the patients had quite recently taken solid food. Such cases are very exceptional. As is well known, patients operated upon in the early morning, when the stomach is quite empty, are less prone to after-vomiting than those operated upon later in the day. I have repeatedly noticed that patients anæsthetised at 8 A.M. are very rarely attacked by nausea and retching afterwards—a fact which may probably be explained by supposing that tea, coffee, &c., which may be considered necessary before operations fixed for 9 A.M. or later, have not been given. When much blood has passed into the stomach during the operation, vomiting will almost certainly follow;

and the same is more or less true with regard to mucus and saliva.

Secondly, as to the anæsthetic itself, we have seen (p. 111) that of all the anæsthetics nitrous oxide is least likely to be followed by vomiting, but there are certain highly exceptional cases in which even this anæsthetic cannot be inhaled without nausea and retching occurring. Moreover, the longer the inhalation, the greater will be the tendency to vomit—hence the slightly greater liability to this symptom when nitrous oxide is inhaled with oxygen. With regard to ether and chloroform, we may say that the administration of the former is more often followed by transient retching than the administration of the latter. But, as has been pointed out, severe, protracted, and dangerous vomiting is more common after chloroform.

Thirdly, some patients are far more prone to these after-effects than others. Rosy-cheeked children, young women of good colour and full lips, and flabby-looking individuals with an unhealthy and dusky appearance are much more liable to after-vomiting than others. Such patients nearly always secrete large quantities of mucus and saliva. Thin, spare, and sallow patients, those who have become anæmic from exhausting disease, as well as aged persons, are not often sick after anæsthetics. Patients of 'bilious' habit often suffer a good deal after ether or chloroform—a fact recognised by Snow.[1] The administration of an appropriate purgative (p. 77) is said to diminish the chances of after-sickness.[2]

Fourthly, the nature of the operation may have its influences. Patients who have undergone operations in which the intestines have been freely manipulated are said by some to be specially liable to after-vomiting. I am also informed by one of our leading obstetric physicians that the operation of oophorectomy specially predisposes to after-sickness of varying degrees in different cases. Dr. Sheppard states in his notes that he found vomiting to be rare after mouth and jaw operations; and Mr. Rigden (footnote, p. 169) makes the same observation.

Fifthly, the kind of anæsthetic employed must be considered. Although it is difficult to speak positively upon the point, I believe that pure ethylic ether is less frequently followed by nausea and vomiting than the so-called 'Pure Methylated' ether; and it is probable that certain kinds of chloroform may be similarly superior to others in this respect.

Lastly, jolting the patient about during recovery from deep anæsthesia will often induce vomiting. It is important, therefore, that the patient should, whenever circumstances permit, be left undisturbed for some considerable time after the administration has been concluded. The custom of moving patients from the operating-table to the bed immediately after the operation is open to the objection that it often leads to vomiting. I have frequently known vomiting to be set up by simply moving the bed back to its position just after the operation.

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[1] *Op. cit.*

[2] I am told by a head-nurse at one of the surgical homes that this is an important point in the avoidance of vomiting.

If, then, we wish to avoid after-vomiting, the previous diet of the patient should be carefully regulated, and an appropriate laxative or purgative given; a deep anæsthesia with the purest anæsthetic should be maintained, with the head upon its side, in order to avoid the swallowing of mucus and saliva; the patient should be turned upon his side, if possible, immediately the operation is completed; and he should then be allowed to remain undisturbed in order that he may sleep off the effects of the anæsthetic.

But if nausea and vomiting arise, and prove distressing to the patient, an endeavour must be made to relieve them. It is best, in the first instance, to give about five or six ounces of hot water to drink. Small pieces of ice were formerly advocated, but hot water seems more efficacious. I have frequently known a draught of hot water to immediately and finally arrest distressing retching. Should it not do so, some strong hot coffee without milk or sugar may be next tried.[1] I have notes of a case in which this treatment allayed vomiting which had lasted for twenty-four hours. When it does not relieve, I have known 10–15 grs. of bicarbonate of soda in very hot water to answer well. I have also notes of a case in which obstinate after-sickness was immediately stopped by champagne; and a case has been reported to me by a surgeon, in which obstinate nausea and retching after chloroform yielded to small doses of oxalate of cerium, after other remedies had failed. Kappeler recommends the application of an ice-bag to the epigastrium for after-sickness; but I have had no experience of this remedy. I find that the disagreeable taste left in the mouth after the inhalation of ether is best treated by giving the patient very thin slices of lemon with which to moisten his lips from time to time.

Incautious ventilation should be avoided, owing to the risk which would otherwise result of giving the patient bronchitis, or even pneumonia. The room should be kept as quiet and dark as possible, in order to encourage natural sleep.

The special after-effects of each anæsthetic have been considered in Part II. of this treatise. Hysterical and other forms of excitement are referred to on pp. 111, 171, and 236; bronchitis, pneumonia, and pulmonary œdema on pp. 170 and 236; albuminuria, nephritis, and glycosuria on pp. 112, 170, and 236; hemiplegia and aphasia on pp. 112 and 171; choreiform movements on p. 171; and insanity on pp. 112, 171, and 236.

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[1] Dr. Buxton ('Anæsthetics') speaks highly of the addition of bicarbonate of soda to coffee.

[illegible]

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